BELL TELEPHONE QUARTERLY

VOL. XIV JULY, 1935

WIDE BAND TRANSMISSION IN SHEATHED CONDUCTORS

DUST STORMS AND TELEPHONE SERVICE

ELECTRICAL COMMUNICATION: PAST, PRESENT, FUTURE

THE CHANGING YEARS AS SEEN FROM THE SWITCHBOARD

THE WORLD'S TELEPHONE STATISTICS, JANUARY 1, 1934

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

CONTENTS FOR JULY 1935

PAGE

Wide Band Transmission in Sheathed Conductors—*O. B. Blackwell* . . 145

Dust Storms and Telephone Service—*G. J. Van de Steeg* 156

Electrical Communication: Past, Present, Future—*F. B. Jewett* 167

The Changing Years as Seen from the Switchboard—*R. T. Barrett* . . 200

The World's Telephone Statistics, January 1, 1934—*K. Fick* 218

Notes on Recent Occurrences 229

VOL. XIV NO. 3

PUBLISHED QUARTERLY FOR THE BELL SYSTEM BY THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY. SUBSCRIPTION, $1.50 PER YEAR, IN UNITED STATES; SINGLE COPIES, 50 CENTS

Address all communications to

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

Contributors to this Issue

O. B. BLACKWELL

Massachusetts Institute of Technology, B.S., 1906. American Telephone and Telegraph Company, Engineering Department, 1906–1914; Transmission and Protection Engineer, 1914–1919; Transmission Development Engineer, 1919–1934. Bell Telephone Laboratories, Director of Transmission Development, 1934–1935; Manager of Staff Departments, 1935–. Mr. Blackwell's individual contributions to the field of telephone transmission have had a wide influence on the art.

G. J. VAN DE STEEG

Iowa State College, B.S. in E.E., 1909. Cuban Telephone Company, 1910–1912. Automatic Electric Company, 1912–1916. Tri-State Telephone and Telegraph Company, 1916–1918. Northwestern Bell Telephone Company, Plant and Engineering Departments, 1918–1925; American Telephone and Telegraph Company, Operation and Engineering Department, Plant Engineering Division, 1925–1926; Southwestern Bell Telephone Company, General Building and Equipment Engineer, 1926–.

F. B. JEWETT

Throop Polytechnic Institute (now California Institute of Technology), B.A., 1898; University of Chicago, Ph.D., 1902. Several honorary degrees. Instructor in Physics and Electrical Engineering, Massachusetts Institute of Technology, 1902–1904. American Telephone and Telegraph Company, Transmission and Protection Engineer, 1904–1912; Western Electric Company, Assistant Chief Engineer, Chief Engineer, Vice President, 1912–1925; Vice President, American Telephone and Telegraph Company, in charge of Development and Research Department, and President, Bell Telephone Laboratories, 1925–.

R. T. BARRETT

Lafayette College, B.A., 1907; New York Law School, LL.B., 1909. Engaged in practice of law, 1909–1918, and in newspaper work until 1921, when he entered the Information Department of the American Telephone and Telegraph Company. Mr. Barrett has contributed occasional articles to the BELL TELEPHONE QUARTERLY.

K. FICK

Hellerup Gymnasium, Copenhagen, Denmark, B.A., 1916; University of Copenhagen, Cand.Ph., 1918. Danish Government Service, 1918–1924. American Telephone and Telegraph Company, Chief Statistician's Division, 1925–.

Wide Band Transmission in Sheathed Conductors

THE Annual Report of the American Telephone and Telegraph Company for the year 1934 speaks of "A radically new form of transmission cable adaptable for use either overhead or underground on heavy traffic toll or long distance routes." The development referred to and another development covering carrier systems for use in existing cables or cables of similar types may be classed together under the title, "Wide Band Transmission in Sheathed Conductors."

These developments have been well presented in four papers entitled:

"Carrier in Cable"
"Systems for Wide Band Transmission Over Coaxial Lines"
"Wide Band Transmission Over Balanced Circuits"
"The Electromagnetic Theory of Coaxial Transmission Lines and Cylindrical Shields"

The first of these was presented at the summer convention of the American Institute of Electrical Engineers in 1933. The others were presented at a similar convention in January of this year. Other technical papers have covered important features of these developments, notably a paper on "Stabilized Feedback Amplifiers" presented at the 1934 midwinter convention.

The present article has been prepared in response to the suggestion that readers of the QUARTERLY may be interested in a brief discussion of certain of the outstanding technical features that these papers have presented.

TECHNICAL FEATURES

These papers all deal primarily with forms of telephone circuits in "cable." Where such cable construction is employed,

the circuits will generally be included in lead sheaths, the diameter of these sheaths being no larger and frequently much smaller than the diameter of full size telephone cables.

For routes carrying many circuits, cable has advantages which are well recognized in the telephone art. It is exactly for such congested routes that these new developments have an important field. They will have, as do other forms of sheathed conductors, the great advantages of an impervious metal wall which shuts out the weather except for its temperature changes and minimizes the effect of outside electrical fields such as those produced by adjacent power circuits. When the cables are placed underground, temperature changes penetrate very slowly and physical hazards are lessened.

It is characteristic of these systems that each wire circuit carries a wide frequency range. This idea is not wholly new to telephone people, since it has been common practice for some years for pairs of open wires to carry frequency ranges to an upper limit of around 30,000 cycles. These new systems are remarkable in that the wide range is applied to sheathed circuits, which have the inherent inefficiency of any circuit in which the wires are close together, and in that the frequency ranges transmitted do not stop at the present limits of open-wire circuits but go boldly up to possibly 60,000 cycles in existing cables and to one or more millions of cycles for circuits in specially built cables.

Such systems would be of little use for telephone purposes were it not for the fact that each wide frequency band can be readily carved into slices of just the right width to carry any desired type of communication. These slices may be 4,000 cycles wide to transmit telephone messages, somewhat wider for program circuits, only 100 or 200 cycles wide for telegraph transmission, and one or more millions of cycles wide if television circuits are required. It is not possible, however, to make very sharp edges to these slices. Because of this a region along the borders of each slice can not be effectively used

for the transmission of the message but must be left to prevent adjacent messages overlapping into each other. For example, each ordinary telephone circuit probably will be given a width of somewhat over 2,800 cycles. The difference between this and the 4,000 cycles taken by each telephone slice represents these separating regions.

This idea of slicing up frequency ranges is also not new to telephone people, since in the open-wire carrier systems now employed the total range up to 30,000 cycles is divided into six one-way carrier telephone circuits, leaving the lower end for an ordinary telephone circuit. The remarkable features of the new developments are the extent to which this slicing has been carried and the methods employed. Let us assume, for example, a one-million cycle band, and further assume that the lower 100,000 cycles is discarded. This still leaves a 900,000-cycle band in which there is room for some 225 slices, each of the width required to carry a one-way telephone circuit.

Since the power losses suffered by currents passing over a wire circuit increase with the frequency, these wide bands in sheathed construction necessarily mean that the high frequencies die out very rapidly as they travel along. To overcome this, it is necessary to place vacuum tube repeaters at frequent intervals. We have come to think of around fifty miles as a normal repeater spacing for cables. For these new systems, repeaters will be spaced perhaps at twenty mile intervals or less for the lower frequency ranges and ten mile separations or even shorter for those transmitting very high frequencies. This close spacing of repeaters is made practicable by recent developments in the form of amplifiers, as discussed later. Since each repeater handles the whole range of frequencies passing over the circuit, the cost of the repeater may be divided among the many separate communication channels which it carries.

Separate circuits in sheathed cable must necessarily be close neighbors. Crosstalk between them has long been an out-

standing technical problem. In general, not more than about a millionth of the power in a telephone circuit may be permitted to pass over into an adjacent circuit. As the frequencies are increased in ordinary types of cables, the problems become more difficult. For the frequencies involved in these systems, it is necessary in some way to take advantage of the fact that if circuits are separated from each other by metal shields their effect on each other is very much reduced.

The first difficulty which appears in using high frequencies is where groups of circuits transmitting messages in one direction are adjacent to groups of circuits transmitting messages in the opposite direction. This is due to the fact that large energies may be going out, for example, from a repeater station, on circuits of one of the groups, while the other group is receiving very small energies from some distant repeater station. The first use of shielding, then, is the simple one of placing the groups of circuits transmitting in one direction in a cable separate from that carrying the groups of circuits transmitting in the opposite direction. Where transmission in the two directions is thus kept in separate cables, it is possible to transmit up to, say, 60,000 cycles over a considerable part of the conductors in existing cables by means which have been developed for improving the balance of the different circuits to each other. This consists of installing, in each repeater section, sets of little coils and condensers between a large number of combinations of wires in each cable. We may see considerable use of wide band systems transmitting up to about 60,000 cycles along the existing cable routes where separate cables are available for transmission in each direction.

If we keep to this same idea of having the two directions of transmission in separate cables, it is possible to build new cables of so greatly improved balance that very high frequencies can be transmitted over them without mutual interference. For such new construction, it is also possible to put

the two directions of transmission in one cable if we divide it by shields into two parts.

A more flexible arrangement is made by wrapping a metallic shield around each individual pair of wires. This permits properly constructed pairs to transmit frequencies of a million cycles or more and yet be bundled together without considering in which direction each is transmitting. Another form of construction consists of a central wire surrounded by, and insulated from, a flexible outer tube of metal. This has become known as the "coaxial circuit." It may be thought of as starting with a shielded pair of wires with one of the wires removed and the shield itself used as the return conductor. It is a nice question as to the relative advantages of the shielded pair and the coaxial circuit. At voice frequencies and for some distance above, the pair is preferable because the shielding effect of the outer conductor is not large at low frequencies and the symmetry and balance of the pairs are needed to prevent mutual interference between adjacent circuits. For wide bands extending to very high frequencies, the lower part of the frequency range may be left idle with little loss. For the high frequencies, the shielding effect is so perfect that the balance of the pairs is not important. It is proposed to make a trial installation of a circuit of the coaxial type.

There are many interesting developments connected with each of the new features of these systems. Of particular importance is the form of amplifier used. In this, some of the energy from the output is carried through special circuits and put back into the input in such a way as to lower the amplification but obtain remarkable stability and freedom from distortion of the amplified currents. The amplification used in each repeater is over one thousand times the amplification which has been used in the carrier system on open-wire lines. The powers in the transmitted messages are allowed to go down to the point where the noise due to the motion caused by heat of the molecules of the conductors becomes the limiting considera-

tion. Convenient modulators and demodulators are made of solid material rather than vacuum tubes. Electrical filters make use of mechanical elements. Automatic regulators hold the transmission efficiencies of the circuits closely constant, independent of temperature variations or other changes.

It is not necessary, however, to go deeply into these interesting features to understand the broad principles involved. Essentially we have: (*a*) closely spaced circuits surrounded by sheaths; (*b*) shielding playing a very important part in preventing interference into and crosstalk between the circuits—this possibly carried to the point of having each circuit consist of a single wire entirely surrounded by a shield, the shield acting as the second wire of the circuit; (*c*) each circuit containing many repeaters but transmitting through them a wide band of frequencies; and (*d*) arrangements at the terminals to carve such a wide band into slices of just the right size and to place the corresponding types of communication into them.

Viewpoints

One type of person likes to think of any new development as a fulfillment of the past and delves deeply into the history of the art to find the beginnings of the ideas which have created it. Another type appears more interested in the newness of the methods employed and takes delight in noting how completely the development departs from past practices. It so happens that these present developments can well satisfy an observer with either of these viewpoints.

For the first, we may note that in the use of a high-frequency range, with the messages separated by selective devices from each other, these systems are closely related not only to our carrier systems over wire but to radio. We may note, further, that before radiotelephone methods were known, crude forms of carrier telephone systems over wires were invented and experimented with to some extent. For telegraph, we can go back to Dr. Bell himself, who, when he invented the telephone,

was working on a telegraph system in which a number of messages could be transmitted simultaneously over a wire circuit using different frequencies.

For the second of these types of mind, there are many features of the systems, each of which is a striking departure from the past. We are already accustomed to tremendous amplification in ordinary cable circuits; but consider what is involved in transmitting the wide bands through sheathed conductors! If a commercial call is now put up over cable facilities, say from Bangor, Maine to Fort Worth, Texas, the total power amplification involved is 10^{120} (equal to the figure 1 followed by 120 ciphers) under average conditions, and more under highest temperature conditions. This is the ratio of the energy actually received over the circuit to that which would be received without amplifiers, supposing, of course, that the minute amount was not lost in interference. This ratio has been picturesquely stated as about that between the volume of the electron and the volume of the universe as suggested in Jeans' book on "The Universe Around Us." If we consider, however, the transmission of a million cycles through a coaxial conductor of about one-third inch in diameter over a 3,000-mile cross-country circuit, we have a power loss of about 10^{1800}, which, it will be noted, is the present tremendous amplification of the Maine to Texas call multipled by a ratio represented by the figure 1 followed by 1,680 ciphers. Moreover, this tremendous amplification must be maintained by automatic regulation so closely to that of the total loss in the cable, that the resultant difference will not vary more than that which would be caused by a few miles of 19-gauge cable in an ordinary circuit.

A frequency range approximately a million cycles wide contains all the ordinary broadcasting channels in this country. One of these proposed million-cycle wide circuits will then transmit a frequency range as wide as that used in such broadcasting. This range, furthermore, it is proposed to divide into

over 200 telephone channels. Incidentally, any one of the telephone channels can itself be carved into a dozen telegraph channels.

The comparison between a coaxial circuit of perhaps one-third inch diameter carrying a million cycles and the methods used in radio transmission for a similar frequency range is very interesting. In the radio case the waves are of comparatively great power spread out over a tremendous area. In the sheathed conductor case it is as though a little bit of space is taken in the form of a long tube of small diameter extending for long distances but this space so carefully shut off from all its surroundings and so carefully adjusted and controlled that hundreds of independent messages of low power can be simultaneously transmitted through the narrow region.

Since the early days of telephony, the use of ground return circuits with their inherent unbalance has been confined to outlying country regions. Balance has become one of the primary considerations of the telephone system, particularly for toll purposes. These wide band systems involve two outstanding developments as regards balance. First, in connection with the use of wide bands in existing cable, balance has been necessarily carried to a refinement which is far beyond anything ever before attempted. In the very high ranges, moreover, as already noted, it is quite possible that balance will be entirely abandoned, complete dependence being placed on the shielding effect of the shell forming a part of the coaxial circuit; thus the art returns for such systems to an unbalanced circuit.

Not the least of the departures from past practice concerns the use of telephone repeaters. On the present cable toll routes, repeater stations are separated at intervals of around fifty miles. These stations may each contain a considerable number of repeaters. They are equipped with testing arrangements and with highly reliable power supply. For most of the time they are attended by maintenance people. With these new systems, stations of somewhat similar form and sep-

aration will be required, although the number of repeaters may be reduced because of the large number of channels carried by each repeater. In addition, these new systems will require repeater stations intermediate between these principal repeater stations, the number depending on how wide a frequency range is being transmitted over the circuits. As already noted, the spacing between repeaters on very wide band systems may be as short as ten miles or less. All of these repeaters could not be handled in the same manner if the systems are to remain economical. To meet this changed situation, repeaters are being developed to be self-contained units of such size that a small number may be placed in manholes, hung on poles or housed in other convenient ways. They must be of such form and so housed that they can operate for considerable periods without attendance. To insure further against failure of these unattended repeaters, the current to operate them may pass over the wires in the cables themselves.

In the "filters," which are the selective devices which play a highly important part in carving up the frequency ranges, there is an interesting departure from past practice in the use of mechanical vibrating elements in place of electrical resonances. The communication engineer has generally felt that electrical circuits had possibilities of flexibility and control far beyond anything that mechanical devices could afford. We have in these filters, however, a deliberate use of mechanical vibrating elements because such elements vibrate with less energy loss than any electrical circuit which can be devised at comparable cost.

Use of Wide Band Systems

Although our Laboratories are well advanced in the forming of these new systems, considerable further development work is required for commercial application. Furthermore, the time of the introduction will depend upon a great many factors, in-

cluding the demand for additional large groups of communication facilities. Their practical introduction is, therefore, not immediately contemplated and in any event will necessarily be a very gradual process.

The plant of the Bell System is so extensive and includes so many different conditions that the picture we get as to the use of these developments depends a great deal on where we look. It is perfectly evident that if we confine our attention to the important routes between the large cities in the highly industrialized sections of the country, there are large possibilities of caring for further growth, first, by application of these developments in the lower frequency ranges to existing cables, and later by the still wider frequency range systems as further growth takes place or replacements of plant become necessary. If we take the toll plant as a whole, we are met by the fact that in any country-wide system giving universal service, there are necessarily long stretches and a large total line mileage where the demands for facilities are not heavy. For such situations, no forms of sheathed conductors can now compete economically with open-wire circuits. The use of the systems will also be considerably influenced by the results of the effort being made to make them available for comparatively short lengths.

A factor in attempting to assess the future use of these developments is television. The development of television transmitting and receiving equipment has made large advances in recent years. Along with this, however, has come an increasing realization that only the tremendous frequency widths of a million cycles or more will give worthwhile results. The transmission of these very broad bands forms a highly important part of the over-all technical problems of television. The transmission problems start with the production of the currents at the point where the interesting event is happening, and continue to the points where the currents enter the receiving sets. This transmission may involve radio broadcasting stations and the sets receiving from them. It may also involve circuits

extending from the pick-up point to these broadcasting stations or to other distributing centers. Whatever may be the final field of television, these wide band developments represent an outstanding contribution to the solution of the transmission problems involved.

O. B. BLACKWELL

Dust Storms and Telephone Service

Editor's Note:

The following report to the Chief Engineer of the Southwestern Bell Telephone Company by the Company's General Building and Equipment Engineer refers to a sectional situation but is printed here because of its general interest to all readers of the BELL TELEPHONE QUARTERLY *who are concerned with the maintenance of telephone service under unusual conditions.*

THE dust storms which have raged intermittently through the western Great Plains area for the past year and a half have been called to the attention of nearly everyone living east of the Rockies, either through the newspapers or by personal observation. The heavy rains of May have turned much of the dust bowl into a sea of mud, and the memory of the dust storms, like most catastrophes, is rapidly fading into the past, except, perhaps, to those most intimately concerned. Nevertheless, it seems appropriate and of probable interest at this time to review this great phenomenon, its causes and effects, and especially its reactions upon the telephone service in the areas immediately affected and those contiguous thereto.

The general area within which these storms originated is indicated in Figure 1. This coincides, in general, with what is quite commonly known as the dry farming regions of West Texas, Oklahoma, Kansas, Nebraska and the Dakotas. It is interesting to note that in this area there is raised on an average about one-third of the total wheat crop of the United States. The territory most affected by the storms includes this area of origin and also as far east as the Mississippi River. While the effects were observed still further east, they were more in the nature of a transient phenomenon. Dust from these storms has been reported as far distant as New Hamp-

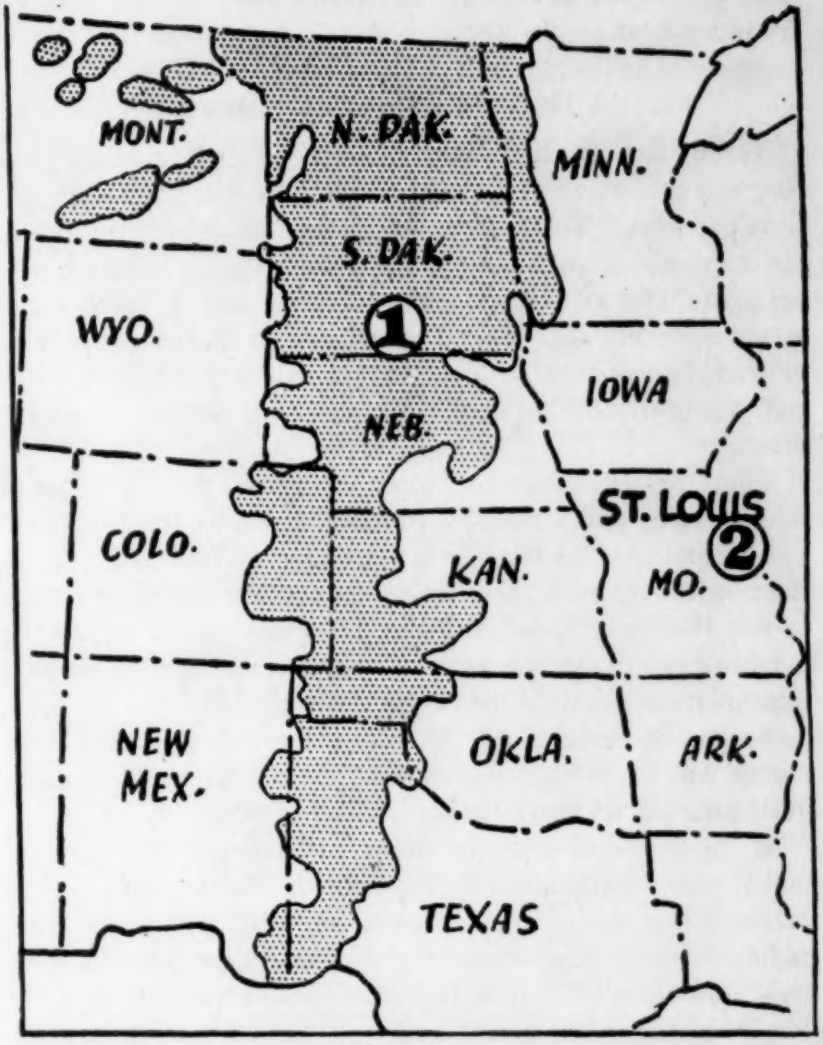


FIG. 1. THAT DUST EROSION IS NOT AN ISOLATED PROBLEM IS INDICATED BY THIS MAP. EROSION WAS MOST SEVERE IN THE DRY-FARMING BELT (1) EAST OF THE ROCKY MOUNTAINS FROM WESTERN TEXAS TO THE CANADIAN BORDER. WITH A PREVAILING WESTERLY WIND DURING MOST OF THE SPRING, THE DUST CLOUDS WERE CARRIED OVER A VAST AREA IN THE MISSISSIPPI VALLEY, OF WHICH ST. LOUIS (2) IS THE CENTER.

shire and points in the Gulf of Mexico and even out over the Atlantic Ocean.

A Description of the Storms

Throughout the areas most seriously affected, a bright clear day was rare and the air most of the time was filled with fine dust particles. The more severe storms occurred with almost the suddenness, although not the accompanying violence, of a tornado. Out of a comparatively clear sky a black cloud would suddenly appear, and within ten or fifteen minutes an entire town would be enveloped to the extent that visibility was reduced practically to zero, and breathing became extremely difficult.

These severe storms frequently continued for six or seven hours, during which business practically ceased and people remained indoors. A number of instances are reported wherein the residents of even small towns became lost and were unable to find their way home until the storm had subsided. At the height of one of the storms, a passenger train failed to make a scheduled stop because the engineer was unable to see the town as he passed through it. As a rule the railroads, bus companies, and state highway officials ordered all traffic stopped during the worst periods, in the interest of safety.

At the height of a severe storm, the darkness was so great that it was literally much darker than the darkest night. The darkness was almost impervious to the headlights of an automobile or even of a locomotive, due to the presence of such great quantities of dust in the air. Some appreciation of the density of these dust clouds may be obtained from the accompanying photographs. Figure 2 shows the approach of the dust clouds. Figure 3 was taken on the main street in Garden City, Kansas at 5:15 on the afternoon of April 14, 1935, and Figure 4 from the same point fifteen minutes later.

The densest dust clouds were, of course, formed by the higher velocity winds, the highest recorded being in the order of 38 to

40 miles per hour. These high winds carried such great amounts of dust that drifts were deposited against fences and across highways and in some cases almost covered farm buildings. Some idea of the drift deposits may be obtained from Figure 5, which shows the piling up of dust along a railroad right-of-way. The pole line in the background is a section of the Kansas City-Denver line between Ingalls and Garden City, Kansas. The rather startling effects of the drifting dust are also illustrated in Figure 6, which shows a tractor practically buried.

In addition to the drifts, great quantities of dust were gradually deposited after the full force of the wind had subsided. Figure 7 shows the dust being removed from the Telephone Building lawn at Dodge City, Kansas, after one of the worst storms of this year. In Figure 8 the dust removed from the Telephone Building lawn at Garden City has been collected into one pile containing approximately two tons of deposit. This was taken from the grass plot, which measures 15′ x 30′. At the State Experimental Farm near Garden City, the dust removed from the lawn was weighed and estimates made indicated a deposit of 350 tons per acre.

The effect of the storms was, of course, most severe in the immediate dust bowl area, but extended as far east as St. Louis with severity sufficient to diminish the sunlight and cause decided discomfort to inhabitants. Cities west of St. Louis and, of course, nearer the dust bowl, such as Kansas City and Oklahoma City, were affected to a considerably greater extent than was St. Louis. A peculiar phenomenon attending these storms was the steel-blue appearance of the moon and even of the sun at midday because of the dust in the atmosphere. At points as far removed from the dust origins as St. Louis, there was the depressing reaction due to the lack of sunshine and the feeling that valuable property was being destroyed in neighboring states. Housewives were more materially affected, as shown by their endeavors to keep their homes free from dust.

The dust clouds were composed of the more finely divided particles which make up the top soil of the high plains regions. The principal constituents are quartz and the silicates of aluminium, sodium, potassium and calcium, with some organic matter. The particle sizes vary between rather wide limits, but the majority have been found to be close to four ten thousandths (.0004) of an inch in diameter. This dust is so fine and clings so closely that it is almost impossible to remove it by ordinary sweeping or dusting methods.

Causes of the Dust Storms

Now, as to the causes of the dust storms. The impression that these storms are new to the high plains regions should be dispelled. While the storms of the past year and a half have been of unusual severity, dust storms have been a rather common occurrence for many years. As a matter of fact, they were recorded in Kansas as early as 1830, when a Rev. Isaac McCoy reported encountering dust storms during an expedition leaving Ft. Leavenworth, Kansas, in September of that year. His description is similar to that of present day storms.

The reason for the unusual severity of the recent storms is probably a combination of several factors. An enormous acreage of pasture or grazing land had been broken and placed in cultivation during and immediately following the World War, due to the high price of wheat prevailing at the time. The level nature of the country and the low cost of the land were favorable to the use of heavy-type planting and harvesting machinery, and wheat raising was undertaken on a very large scale. "Dry farming" was extensively practiced and one successful season followed another, with the natural result that more and more acreage was placed under cultivation, and the beginning of the present decade found the high plains supporting a greater population than ever before.

Beginning with the year 1930, however, there have been five successive years wherein the rainfall was either greatly deficient

or ill timed for the support of vegetation. In the western Kansas section in these five years the precipitation each year has been below the average and each year lower than the preceding one. As a natural consequence, vast areas were practically denuded of vegetation and left without protection from the erosive effect of the winds which blow almost continually in the high plains regions.

In its natural state, this prairie country is covered by a thin but tough stand of a short grass known locally as buffalo grass. This is a very effective covering, preventing wind erosion of the soil. During the drouth of the past five years all vegetation, including this buffalo grass, suffered a great deal and, in addition, the grass which remained in the area not under cultivation was grazed more closely than usual in an effort to prevent the starvation of cattle. This further denuded the soil and exposed practically the entire area to wind erosion.

The impression prevails among some that irreparable damage has been done to the fertile soil of this great wheat raising section of the United States. It is the opinion of leading agronomists that while no doubt there has been some damage done to top soil, particularly in the areas affected by the worst dust storms, on the whole very little permanent damage has resulted. In the immediate dust bowl area it amounted to some extent to a transfer of the soil from one section to another and then a re-deposit back, due to shifting winds. In the area outside of the dust bowl region the deposit of fertile dust has, no doubt, enhanced the value and fertility of the soil. It is estimated that in Kansas, out of eight million acres subject to erosion and blowing, only about 350,000 acres have been seriously damaged. Of course, a serious effect is the loss of the wheat crop for 1935, but some authorities feel that the lack of moisture during the winter had in any event precluded a paying crop for this year. The drifted soil, too, presents a problem which will entail considerable expense before these drifts

are removed and spread evenly over the land and the lighter deposit mixed with the heavier soils.

While there have always been dust storms in this region, those best informed feel that the destructive storms of the past few years can be avoided by concerted effort to restore vegetation and by modifying farming methods to some extent. It is probable that a considerable acreage should be returned to its native state and used for grazing purposes. The buffalo grass (Bouchloë Dactyloides) would be ideal for this purpose if it did not present certain difficulties. It is an extremely short grass, the seed matures very rapidly, and immediately when ripe the entire seed head falls to the ground. As yet no way has been developed for harvesting this seed, but at the Kansas State College consideration is being given to the design of a suction type of machine for harvesting it. In addition, experimentation is under way by State and Federal agencies with European and Asiatic grasses adapted to similar dry regions.

For the areas which are under cultivation, a method called "deep listing" is advocated to prevent dust blowing. A lister, or "middle buster," is an implement similar to a plow, which cuts a deep furrow and deposits the upturned soil on both sides, leaving ridges of large lumps of the harder earth. These resist erosion better than a smooth surface and the ridges also serve as small windbreaks. It is understood that the State and Federal authorities advocate a series of five or six listed furrows every twenty rods and feel that the miniature windbreaks thus provided will prevent serious erosion and any great amount of soil being carried away by the wind; and that the Federal Government plans a belt of trees approximately one hundred miles wide extending from the Canadian border southward into the Texas panhandle. This tree belt is expected to serve both as a windbreak and as a means for conserving such moisture as falls in this area and it is hoped will definitely limit the area of erosion. The difficulties of raising trees in this dry region are obvious and a considerable period will, of course, elapse before

FIG. 2. AN APPROACHING DUST STORM.

FIG. 3. ABOVE: THE MAIN STREET IN GARDEN CITY, KANS., AT 5:15 P.M. ON APRIL 14, 1935.

FIG. 4. BELOW: THE MAIN STREET IN GARDEN CITY, KANS., FROM THE SAME POINT, FIFTEEN MINUTES LATER.

FIG. 5. LEFT: A DUST BANK ALONG THE SANTA FE RIGHT-OF-WAY IN THE MIDDLE WEST.

FIG. 6. BELOW: A TRACTOR ALMOST COMPLETELY BURIED BY DRIFTING DUST.

FIG. 7. REMOVING DUST FROM THE LAWN OF THE TELEPHONE BUILDING AT DODGE CITY, KANS., AFTER ONE OF THE WORST DUST STORMS OF THE YEAR.

FIG. 8. REMOVED FROM A LAWN ABOUT 15 X 30 FEET, AT THE GARDEN CITY, KANS., TELEPHONE BUILDING, THIS ACCUMULATION OF DUST WEIGHS ABOUT TWO TONS.

FIG. 9. REMOVING DUST WHICH HAD ACCUMULATED BETWEEN SCREEN AND WINDOW OF THE DODGE CITY, KANS., TELEPHONE BUILDING.

FIG. 10. TELEPHONE LINEMAN EQUIPPED WITH RESPIRATOR, FOR USE WHEN ENGAGED ON NECESSARY OUTSIDE WORK DURING SEVERE DUST STORMS.

it is known whether this project, if undertaken, will prove of any material value.

Effect on Telephone Service

Telephone switchboard equipment in the areas most affected by the dust storms is of the manual type. The nearest offices having step-by-step dial equipment are at Wichita, Kansas; Oklahoma City, Oklahoma; and Amarillo, Abilene, and Wichita Falls, Texas. Amarillo is actually in the dust bowl and the other towns are outside and some as far as 200 miles distant.

In none of these offices has there been any unusual increase in trouble which might be attributed to the presence of dust. No doubt this is due to the unusual precautions which were taken and to the fact that the equipment was in first class working condition as regards cleanliness before the storms. During the storms, the windows and doors were kept tightly closed and the windows sealed either by means of a plastic caulking compound or by the use of a masking tape such as is used by painters and decorators. The advisability of sealing may be more apparent from Figure 9, which shows a cloud due to the removal of accumulated dust between the screen and window on the second floor of the Dodge City building.

In addition, the unit ventilating apparatus which is available in the dial offices was operated on a recirculating basis, thus repeatedly filtering the dust out of the air in the room. Working conditions in these dial offices were very good even during the worst of the storms. In the offices not equipped with unit type ventilators, switchboards and apparatus as well as floors and window sills were cleaned almost constantly in an effort to prevent accumulations of dust. In the office at Dodge City during one of the most severe storms, the outside working forces were called in to help and the entire switchboard and other equipment were cleaned and the floors mopped seven times in one day. Since some trouble was experienced with dirty relay contacts, the contacts were cleaned and certain of

the relay covers sealed with friction tape to prevent recurrence of the dust trouble.

At one of the connecting company exchanges, the Southwestern Company has a "D" type carrier system which repeatedly developed dirty contact trouble. In order to eliminate this difficulty the carrier equipment was completely enclosed in a box made of wall board which prevented a recurrence of the trouble. As might be expected, there has been some slight increase in central office switchboard troubles and also some at private branch exchange switchboards. These were minimized by frequent routine testing and cleaning, and in some cases even vacuum cleaning after storms was resorted to. By these means much potential trouble was prevented and no serious complaints were received from subscribers.

The very slight increase in station troubles including dials was surprising. In general, the outside plant suffered very little and the only trouble experienced was due to dust collecting in cable terminals, particularly the 14 type. Later, when rains came, some leakage troubles developed due to the combination of dust and moisture. A thorough cleaning eliminated this difficulty.

The most serious handicap to sustained good service was caused by static discharge from rural and toll lines. It appears that, with the extremely dry conditions prevailing, the fine particles of dust and sand in their passage through the air accumulated an electrical charge which upon contact was transmitted to the open wire lines. The effect of these charges was a severe popping noise similar to that experienced at times on the radio and this was frequently severe enough to make conversation difficult or even impossible. Also at times the discharges caused slight shocks to the operators at the switchboards. These shocks occurred chiefly on the rural positions when the operator picked up the calling cord in completing calls from metallic rural lines.

There is not available an exact measure of the severity of

the static discharges, although there are stories to the effect that barbed wire fences, radio antennae and similar wires were luminous at times. Relief from the static discharges which caused interruptions to toll and rural service was temporarily obtained by grounding the circuits through suitable high impedances. In the case of the rural lines, this was done by bridging the circuit with 2500-ohm ringer having the center point grounded. For toll lines, relief was obtained by grounding the phantom circuits, if not equipped for telegraph service, or by grounding the telegraph legs if the circuits were so equipped. These temporary expedients proved quite satisfactory.

Another effect of the static was to charge objects such as automobiles, with the result that a large number of people trailed chains or wires from their cars either to prevent accidental shock from a discharge or to eliminate a fancied danger from explosion of the gasoline tanks. This was a common practice throughout the area, although it was not employed on any of the cars in the Bell fleet.

In common with experience in catastrophes of all sorts, traffic loads increased remarkably during most of the storm periods. From April 10 to 14, when the most severe of the storms occurred in western Kansas, the local traffic loads increased to twice the normal amount and the long distance traffic was from 50 per cent to 75 per cent higher than normal. Except when the toll circuits were seriously affected by static disturbances, ample facilities, both local and toll, were available and it was possible to maintain a uniformly good service. In spite of all precautions, the air in the operating rooms at times was so filled with dust that breathing was difficult and it was necessary to give the operators frequent relief for the purpose of clearing their throats of dust and relieving the strain due to talking under such unfavorable conditions.

The daily papers and the news reels may have created the impression that the dust has caused a great deal of illness and

a considerable increase in the death rate due to pneumonia and other respiratory troubles. While there may have been some increase in illnesses of this type and some increase in the death rate, the records of the Telephone Company's Benefit and Medical Department show no increase in illness attributable to the dust. The Plant forces took the precaution of wearing respirators when engaged in necessary outside work during severe storms and Figure 10 shows a lineman so equipped.

While the Telephone Company's attendance and illness records show no increase, it is possible that the dust aggravated some other conditions which led to the reports of serious illness and death. Reports from the Commissioner of Health of the State of Oklahoma state that a careful examination of the people in the counties most affected disclosed only an irritation of the throat and bronchial tubes. However, the reports further state that it is possible at a later date silicosis may develop as a result of dust irritation. It is expected that there should be an increase in difficulties due to nose and throat irritation even though people in these areas protected themselves as well as possible by covering their noses and mouths with handkerchiefs, towels and bandages of all sorts. School teachers were kept busy performing this service for school children before sending them home and it was reported that in some households one member of the family stayed awake during the night keeping the noses and mouths of the other members covered while they slept.

In conclusion it can be said that while the conditions during the dust storms were extremely severe, yet the records and statistics show little, if any, reaction on the quality of the service. That this is so is due largely to the excellent condition of the telephone plant, to the high quality of maintenance, and especially to the fine spirit of coöperation shown by all of the operating forces.

G. J. VAN DE STEEG

Acknowledgment is made to the Conard Studio, Garden City, Kan., for the use of photographs, and to the St. Louis *Star-Times* for the use of the map showing the area affected by the dust storms.

Electrical Communication: Past, Present, Future

AN ADDRESS BEFORE THE NATIONAL ACADEMY OF SCIENCES IN WASHINGTON, D. C., ON APRIL 22, 1935 *

FROM time to time during the past twenty years there have been presented at the meetings of the National Academy of Sciences demonstrations of outstanding scientific and engineering achievements in the field of electrical communication. These papers and demonstrations have been portrayals of the striking advances that have been made. They have covered such things as loud speaking telephones and public address systems when they were looked upon as new achievements; various aspects of wire and radio transmission; television; and the transmission and reproduction of orchestral music in perfect auditory perspective.

None of them, nor all of them together, nor all of similar discrete presentations of scientific and engineering progress, can portray properly the philosophy, science and art of electrical communication. In a way, such presentations tend to give a false understanding of what electrical communication really is and of the place it occupies in the social life of the world. Things of this kind, although extremely important, are merely spectacular eminences in the main topography. Viewed alone, they may satisfy our curiosity and provide us transient pleasure and excitement. Viewed against an understanding of the philosophy which underlies the development of electrical communication, they can do all of this and at the same time give us

* More recent statistics are used in this article than were available when it was delivered as an address in Washington, and some of the material has been slightly rearranged for publication.

a real understanding of the level to which the main topography may be raised.

If you here tonight have come in anticipation of witnessing something similar to the transmitted concert which was given in Constitution Hall a couple of years ago, you are destined to a distinct disappointment. It would be easy to produce something of the kind, but what I have chosen to do is to present the other and more important side of the picture as I see it. Probably it may appeal to you as a drab affair, but I hope that it will serve to tie together some of the presentations of the past and likewise to serve as a fiduciary plane for such presentations and demonstrations of electrical communication advances as may be given in the years ahead.

Two Anniversaries of Historic Importance

Three months ago there passed, with hardly a notice even among communication people, the twentieth anniversary of the day on which transcontinental telephony was established for the first time. In New York on that day two decades ago, Alexander Graham Bell, his hair and beard whitened with the passing years but using the same instrument into which in Boston thirty-nine years earlier he had spoken the now historic words "Mr. Watson, come here, I want you," again spoke to his friend. Once again he and his friend, the instrument which was the child of his brain, and his historic words, phrased in the somewhat courtly fashion of the time, were inscribing indelibly a page in the book of human history.

This time, however, it was a page consciously prepared for history's book. The actors, the instrument, the very words had been lifted from their shrine and brought forward to float once more for a moment on that stream which never turns backward except when man plays with pageantry, sentiment and love. On this occasion it was a bit of pageantry, something of sentiment and much of love which inspired the act. Nor did the scene from an older era appear to us who were

spectators as inappropriate or out of keeping, even when interpolated in a very modern play. Even the stately language, so foreign to our daily usage, in which the young assistant was addressed, seemed eminently fitting for these participants on such an occasion—anything else would have made the play a burlesque.

One thing only had to be different from the original—the finale. Not again could Mr. Watson play his part by responding to the summons in person, for this time he was three thousand miles away in San Francisco. But he obeyed the command in spirit and in word, and Mr. Bell and all of us who were present heard the reply and knew that another great dream had come true.

A few weeks hence, before most of us are beginning to enjoy our summer vacations, another twentieth anniversary in electrical communication will occur. Probably it too will pass by essentially unnoticed, despite the fact that the event which it will signalize marked not only a monument in the course of electrical communication but likewise the beginning of one of the most astounding eras in the whole history of science. It is an era in which we still live and in which there is as yet little evidence of diminution of the new forces of science which the events of twenty years ago in the field of communication brought into being.

In the spring of 1915, after years of painstaking foundation research climaxed by hectic months of final preparation under conditions where normal difficulties were enhanced a thousand fold by the growing agonies of a World War, human speech was projected across the Atlantic for the first time. Washington spoke to Paris and to Panama and Honolulu and there were no longer any frontiers to telephony, though ten years were still to elapse before commercial service was possible.

Even though we sophisticates of 1935 may take the happenings of 1915 as matters of course, the two developments in communication just mentioned were matters of first importance

at the time. For days and weeks they superseded or paralleled the reports of battles in Europe and for months they filled the magazines with discussions, learned and otherwise, of their future effect on human affairs. In the scientific world the efficacy and power of the physical tools which had made possible transcontinental and transoceanic telephony were at once apparent and journeys began into the fields of improved sound recording, radio broadcasting, talking motion pictures, picture transmission and television, not to mention a thousand and one minor fields of electrical communication and other fields far removed from it.

Quite aside from any influence in collateral fields, the purely communication achievements of 1915 set that year apart as one of the few truly noteworthy years in the annals of telegraphy and telephony. In telephony it is second only to the year of Bell's invention of the telephone itself. It is the year in which man, through science and engineering, gave final answer to the challenge with which from the beginning of time Nature had confronted him. Before 1915, Nature could say to man, "There are limits of distance beyond which you cannot go in free, intimate personal converse with your fellow men; you must work out your destiny within this limitation." After 1915, man could say to Nature, "There are no limits of distance or physical circumstance which you can longer impose on me as regards my need or desire to speak face to face with any man anywhere; from now on I propose to work out my destiny free from this shackle of the past."

So much for a bit of history as a prologue to and justification for an address in 1935 on Electrical Communication. Despite the three equal divisions of the subtitle, I promise to tread lightly in the realms of the past—only enough to elucidate the present and the future. What I should like to do is to give you a thumbnail picture of electrical communication as we have it today and something of the view I have of it in the future. I

do not intend to be technical, for that would interest only physicists, chemists and engineers—possibly not even them.

The Common Bases of Electrical Communication

What I hope to do, after giving you a very brief outline of the scientific and technical basis of electrical communication, is to picture for you something of the art which has developed during the past sixty years and something of the philosophy which has guided that development. If possible, I should like to fit the separate fragments of the mosaic together so that you will see them for what they really are, namely, integral parts of a single common whole. Such visualization is necessary for a complete understanding. It makes no difference whether your approach is from the realm of science and engineering, from that of commerce, industry or social reactions, or from that of political government seeking to adjust a new art to an old but changing way of living. Unless you can see the picture of electrical communication in full outline, any effort directed merely at a part, whether technical or otherwise, is more likely than not to be abortive in its permanent results.

Partly because of the somewhat fortuitous way in which the several fields of electrical communication have developed, partly because of the vested interests involved and which think themselves in conflict, and partly because of a deep-seated though erroneous set of classifications, it is not easy to visualize this complete picture. Without it we are prone to think and, what is worse, to act in terms of telegraphy, telephony, radio broadcasting, telephotography, or television, as though they were things apart. Possibly our worst sins in this direction are to be found in the fields of business and governmental supervision and control, but science, engineering and social usage are not exempt. To some extent these wholly artificial and misleading classifications have been and are consciously perpetuated by those whose special interests will be served thereby.

For the rest, however, the difficulty is a failure to realize vividly that, one and all, they are merely variant parts of a common applied science. One and all, they depend for their functioning and utility on the transmission to a distance of some form of electrical energy whose proper manipulation makes possible substantially instantaneous transfer of intelligence. Mere transmission of electrical energy in any form does not provide electrical communication. It is the way we manipulate the electrical energy at the transmitting station which gives us our ability to communicate intelligence. Further, whenever and wherever we can transmit electrical energy to a distant point for one form of communication, we can, in general, use that same energy for all other forms of intelligence transmission. Sometimes, to be sure, one form of transmission is better than others for a particular service, but this is usually for reasons of greater reliability, economy, privacy or freedom from inductive interference. Generally, for point to point transmission wire circuits are best, especially on heavy traffic routes, while radio is especially adapted to broadcast transmissions.

In all forms of wire transmission, the electrical energy is always some sort of electric current which is guided by the wire from the sending to the receiving station. The way we manipulate or "modulate" this current at the sending station determines whether we are concerned with telephony, telegraphy, telephotography or television. To make the modulated current humanly intelligible at the receiving station, we must "demodulate" it in some fashion which will reproduce the same physical results as those which existed at the sending station.

In all forms of radio transmission, the electrical energy which is to carry the message is radiated into space at the sending station and is "detected" or picked up at the receiving station. It is made serviceable for intelligence transmission, however, by "modulation" and "demodulation" operations

exactly similar to those employed in wire transmission. Whether the transmission is telephony, telegraphy, telephotography or television depends solely upon which type of signal is used to modulate the carrying current. If the receiving stations at which "demodulation" takes place are multiple in number, the transmission is commonly referred to as "broadcasting," but this does not change the inherent character of the phenomena. Exactly the same results would obtain with wire transmission if wires ran to the multiple receiving stations.

Because of the wide diversity of conditions of service to be given, and of locations to be served, and the wide variety of transmission means available, choice in any particular case or for any particular service is primarily a matter of economics, and not of fundamental science, of engineering or of theories of governmental regulation. This being so, it is extremely unfortunate for the orderly development of an applied science that means so much in human living, that our thinking and acting should have become so involved in non-existent categories and in the complexities of physical apparatus.

While all forms of electrical communication are merely variant adaptations of common physical phenomena, they can nevertheless be divided for convenience into two groups. The basis for this division is not, however, one of the methods of transmission or of the apparatus employed or even of the kind of service given. Rather it is a differentiation based on our physical senses of sight and hearing.

If at the receiving station the interpretation of the message is conveyed to the brain through the ear in the normal function of hearing, it is telephony; if through the eye, it is telegraphy. Using this basis of distinction, all that we commonly call telephony is telephony; so also is all that we commonly call radio broadcast, whether it be news, music or other forms of one-way electrical transmission of information or entertainment registered through the machinery of hearing. We are not concerned with methods of transmission from the sending station,

except that they be electrical, nor are we concerned with the form or character of any apparatus that may be involved.

On the other hand, using this distinction places all telephotography and television as well as all that we commonly designate telegraphy, whatever its form, in the classification of telegraphy. Here also, methods of transmission and kinds of apparatus are not involved.

If some one should question these definitions on the ground that the signals heard and interpreted by the ship radio operator, or the Morse man at the railroad station, are by them made to constitute these services as telephony, the answer is that these are special cases where the ear of the operator has been trained to do something normally performed by the eye.

Added to the help which classification under these definitions is within the field of electrical communication itself, is the material aid which they give when it comes to relating and judging electrical communication with other forms of communication.

The Keys to the Delimitation of Distance

Chronologically, as is well known, telegraphy and telephony as here defined developed in the following sequence: wire telegraphy, wire telephony, radio telegraphy, radio telephony, and more recently the beginnings of television. In this they but followed progress in physical research and in the application of mathematical reasoning to physics. Even after Bell's invention of the telephone, long years were to elapse before wire telephony and telegraphy in their technical handling could be treated practically merely as parts of a common art. Long years likewise had to elapse before physical research made practical radio telegraphy a possibility, and still other long years before its advances made possible an extension of this mode of transmission to the field of telephony.

The development of practical radio transmission and the discoveries on which it was based are looked upon as marvelous

advances, and so they were. Largely, however, the measure of the marvel is due to the fact that we had become familiar with wire transmission. If the order of development had been reversed, the discovery of wire transmission by which intelligence could be conveyed from point to point, secretly, with many parallel channels placed close together and using very simple modulating and demodulating apparatus, would have appeared an even greater marvel, when contrasted to a system of limited channel capacity and no privacy except such as might be attained through the use of complex terminal apparatus.

Oddly enough, the advancing knowledge in physics which made possible the adaptation of radio transmission to the requirements of telephony, namely, knowledge of how to produce and control electrons in vacuum, found its first great application in the field of wire telephony. Almost overnight it removed the barrier of distance to voice frequency wire telephony. So powerful was this tool of the electron vacuum tube, taken in conjunction with another great development of mathematical physics which arrived almost simultaneously, namely, the electrical filter, that almost immediately it opened up the entire field of radio telephony and a vast new domain of possibilities in all forms of wire transmission.

In the forty years between Morse's demonstration of a practical wire telegraphy based on the discoveries of Faraday and Henry, and Bell's invention of the speaking telephone, the only practical known method of modulating the line current was by complete interruption. This sufficed for the production of signals at the receiving station which could be interpreted into messages. During these forty years, a great amount of ingenuity was applied to developments based on this form of modulation, and extensive telegraph systems both over land and under the seas came into being for the purpose of expediting the transfer of intelligence hitherto conveyed by mail.

Modulation by interruption was not, however, applicable to

telephony. Bell's invention of the telephone provided a new method of modulation applicable over the frequency range of human speech and hearing. Approximately another forty years elapsed during which tremendous technical and commercial progress based on this new method of modulation was accomplished. Very considerable systems of two-way telephony came into being and, within the limits of their physical possibilities, distance as affecting an interchange of intelligence through speech and hearing was annihilated. The gulf between wire telegraphy and telephony was likewise narrowed by the development of means for providing for both services simultaneously on the same circuit.

There were, however, practical limits of distance to telephony in this period, due primarily to the fact that the strongest modulated current which could be produced by the voice of a speaker became so attenuated by the transmission line as to be inadequate for producing audible signals in the receiver. Prior to 1915, all telephone systems were therefore unconnected islands, large or small, in the universe of speech communication.

In the meantime Marconi, building on the work of Hertz, had demonstrated that practical radio telegraphy could be had by radiating electrical energy of enormously high frequency into space and modulating its flow by the complete interruption method of Morse telegraphy. For fifteen years, however, and despite much research work, there appeared to be no feasible way of employing this new art in telephony.

The situation in the early part of the third decade of the present century was roughly as follows:

1. Wire telegraphy based on interrupted direct current had been in use for approximately eighty years. It had reached a high state of technical development and there were substantially no limits of distance or location to which it could not be extended.

2. Wire telephony based on the use of voice modulated

direct current transmission had been in use about half this time. Commercial two-way telephony had become a vital factor in social and business life but had reached substantially the limits of distance imposed by existing scientific knowledge.

3. Radio telegraphy had made considerable advance, particularly in the marine field and for random services where traffic was sparse or the costs of providing wire line excessive, but was confronted with somewhat the same obstacle as telephony to effective application without regard to distance.

Broadly speaking, the situation in the electrical communication art about 1912 was that of three distinct fields of application—two of telegraphy and one of telephony—which were nearing the limits of their development through engineering application of existing scientific knowledge. Fortunately for electrical communications and for the society it served, fundamental research in atomic and subatomic physics had been going on apace. Out of its results and the equally brilliant results of research in mathematics directed to the problems of electrical communication came the keys which unlocked the confining doors.

The vacuum tubes of Fleming and DeForest and the electrical filters of Campbell were these keys. Neither the vacuum tube, which held the secret of electron control, nor the electrical filter came into the communication art fully grown. Both were embryos, but embryos whose future was clear to those wise in the ways of such embryos.

As a result of appreciation and diligence over a period of less than two years, the research men of the Bell System had so developed these new tools as to push ajar the door of distance blocking wire telephony and the door blocking the application of telephony to radio transmission. Both doors opened on a common passage, and from the time they were opened in 1914–15 there were no longer to be separate compartments for the different kinds of electrical communication.

Development of the vacuum tube gave us first the distortionless amplifier needed to annihilate the distance barrier in ordinary voice frequency telephony, and then the perfect generators, modulators and detectors of high frequency currents needed in radio telephony. Likewise it, together with the electrical filter, opened up to wire telephony and telegraphy the whole field of modulated high frequency currents with their limitless possibilities as compared to mere modulation of direct current. Of course, these new possibilities did not come into being at once and even now, twenty years after the doors were opened, we have in many directions scarcely made a beginning. Even so, however, wire telephony and telegraphy have already at their disposal every scientific or technical device that has utility anywhere in the communication field, and, per contra, radio telephony and telegraphy have many of the tools and techniques of wire transmission. Where a few years ago a single simple channel was limited to one or at most a couple of simultaneous transmissions, we now have the possibility of an equally simple structure accommodating hundreds of non-interfering telephone or telegraph messages, and that without limit of distance.

The American Philosophy of Service

The importance of all this to the electrical communication art and to the society it serves lies not in the multiplicity of things we have or may later obtain, but in the fact that there are no longer any breaks in the science underlying the several parts. So far as the physical machinery of electrical communication is concerned, the engineer of the future will have the whole field to choose from and his choice will be determined in each case primarily by considerations of economics or policy and not by those of a limiting science. It is a condition which he must recognize fully. So, too, must those who direct and determine policy and regulation.

Probably in no field of applied science has man gone so far in the organized control of the forces of Nature and in the regimented operation of them in coöperation with human endeavor as in that of electrical communication. Nor is there any other field, I think, where he has gone so far in the way of making provision to avail himself immediately of every new development of fundamental science that may be serviceable. The marvel of even present-day accomplishments is almost beyond belief.

To pick up a telephone anywhere, ask for a friend who may be separated by oceans and continents, and be told to "Hold the line, please," is to stretch credulity to the limit. To talk with that friend as though he were vis-a-vis, to recognize every intonation of his voice despite knowledge that the electrical energy of transmission has undergone hundreds, possibly even thousands of transformations on the way, is to exalt our respect of man's control over the forces of Nature to a high point.

To sit quietly in one's home and hear in full voice words spoken on the other side of the world and to realize that somewhere along the way, possibly several times, the modulated energy which was conveying intelligence to us and to thousands of others simultaneously had diminished to something less than the amount of energy we could collect from the North Star on our outstreched hands, is to take the whole thing outside the bounds of realism.

Or, as we of this Academy did two years ago, to sit in a great auditorium and listen to a symphony orchestra in a distant city render for us music without flaw or blemish and with effects which neither they nor any human orchestra unaided could produce, is to open the doors to a future such as even Jules Verne never contemplated.

Obviously, an achievement so intricate and vast as the whole of present-day electrical communication has been contributed to by many men in many lands. Their contributions have been those of science, invention, engineering, organization and

operation. With full credit to all others it is, I think, no derogation to say that electrical communication is essentially and most largely an American thing—possibly our greatest and most unique contribution in the field of applied science. Certainly both telegraphy and telephony as arts had their beginnings in the United States and, whatever may be argued about the history of telegraphy, there can be no question as to telephony. Born in America, it has always been and is now the leader and model for other countries.

Just why this should be so, it may be difficult to say with exactitude. Other countries have scientists and engineers as well trained and administrators as able, venturesome and far-seeing. Possibly our lack of tradition and settled modes of life had something to do with it; possibly the adventure of it appealed more strongly to us; possibly it fitted better the tempo of our times; and possibly the fact that it had fifty years in which it could grow and develop essentially untrammeled by a too narrow and detailed dominance of political government was a major influence. Certain it is that, with few exceptions, telephony elsewhere has from its inception or after a brief initial period been either a function of political government or completely dominated by government. Inevitably, it has been subjected to all the restraints which seem to be a necessary concomitant of such government. In a developing art based on a rapidly growing fundamental science, it is fatal to progress and to the fullest fruiting for society to begin setting rigid standards, rules and regulations before you know what it is you are trying to standardize, rule and regulate and before that art has reached the quiet courses of mature life.

But above and beyond all the reasons which may inhere in these factors, it seems to me that the principal explanation of American preëminence in the field of telephony resides in the fact that from the very earliest days of development we have had a definite philosophy and have sought in every way possible to adhere to it. It is a philosophy compounded of faith

in the ultimate possibilities of science and engineering; of a belief that a universal telephony was a powerful and necessary tool for society; of a realization that maximum development of usage required the best possible service the art permitted, at the lowest possible price commensurate with cost and a fair return to those who gave the service. As indicative of the objective of this philosophy, a quotation from the charter of the American Telephone and Telegraph Company, granted March 3, 1885—more than fifty years ago and less than ten years after Bell first exhibited his telephone at the Centennial Exposition —may be illuminating:

> And it is further declared and certified that the general route of the lines of this association, in addition to those hereinbefore described or designated, will connect one or more points in each and every city, town or place in the State of New York with one or more points in each and every other city, town or place in said state, and in each and every other of the United States, and in Canada and Mexico; and each and every of said cities, towns and places is to be connected with each and every other city, town or place in said states and countries, and also by cable and other appropriate means with the rest of the known world, as may hereafter become necessary or desirable in conducting the business of this association.

To appreciate fully the faith and daring of these words, it should be remembered that at the time they were written telephony was an infant thing of small utility and limited scope and that the things of science on which its future was to rest were as yet unborn.

While the philosophy has been primarily that of the Bell System, it has in its main aspects been the guiding principle of all who have sought to develop telephony in the United States. The result is an essentially unified service, despite diversity of ownership. Nowhere else, so far as I am aware, is electrical communication dominated by such a philosophy.

Implicit in the philosophy and explicit in its application for more than fifty years is the ideal of service as a means to an

end, of faith in the ability of science to develop and electrical communication to profit thereby, of a catholic attitude toward any and all means by which service may be extended and improved, of an avoidance of any and all fixed standards which tend to hamper and limit progress and render development their slave rather than their master, and of a belief that men are capable of building up and maintaining a vast and efficient cooperative organization of men and women imbued with and actuated by a common ideal. In operation here in the United States every function of research, engineering, manufacture, installation and operation, of finance, public relations and management, is tested against this philosophy. While enormous progress has already been made, the end of the road is not yet in sight. Principal in the work ahead is the job of science, for while an operating organization can easily fail to get the most out of its physical tools, it can never get more out of them than they contain.

While never specifically enunciated as part of the philosophy, there has nevertheless been from the beginning of telephone development in America a factor inherent in the definition of "best possible service" which for many years and until quite recently directed the growth of American, and at least the larger part of foreign, telephony along divergent paths. In recent years, foreign practice has tended to conform more nearly to that of the United States.

From very early days the American conception of telephony as a "service" has been that of something to be furnished on demand and as nearly instantaneously as possible—not as something to be furnished at the convenience of the purveying organization. The goal of an ideal service has always been that of a "no delay" service, where the two parties are put in communication immediately following the request of the originating party and while he remained at the telephone. Since the normal processes of our daily lives—our waking and sleeping, our business and social activities—are not uniformly distributed

throughout the twenty-four hours, they tend to concentrate our communication desires in certain peak periods. Strict adherence to the "no delay" principle in these peak periods means, therefore, inevitably the provision of much plant which must lie idle the greater part of the time, with consequent greater cost against each unit of usage than if the usage could be more uniformly distributed. It avoids, however, any tendency of the communication machinery to impose artificial restraints on the normal currents of human affairs. It also admits of a simple uniform rate structure without any urge to establish preferred classifications of service.

From the scientific and engineering point of view, it is this "no delay" objective for all telephone calls, more than anything else, which has imposed the greatest incentive and stimulus to intensive research and development. Obviously, a universal "no delay" service can be obtained only if the physical means of communication are so cheap and reliable as to permit a profusion of plant sufficient to accommodate peak traffic without imposing an excessive burden of cost on the user.

While we are still a long way from the ultimate objective, we have during the past ten or fifteen years made appreciable progress, especially over the longer distances, and that too with a diminished cost of service to the subscriber. Except for accidents, substantially every telephone connection anywhere in continental America, whether one calls by number or for a particular person, is now established while the calling party remains at the telephone.

Contrasted with this "no delay" objective was the objective of maximum use of physical plant which for so long dominated most telephone development outside of the United States. While this was intended to reduce unit costs, it opened a Pandora's box and let loose a host of unforeseen difficulties and irritations. It occasioned interminable delays which sometimes amounted to hours on relatively short distance calls, with consequent irritation. To overcome this trouble is necessitated

the introduction of successive classifications of service, each more expeditious and more costly than the others, until for "no delay" service the charges were materially higher than those for the same distances here. At the same time, service at the base rate charge, except at off-peak periods, became unutterably poor.

Finally, the whole scheme acted to force users against their will to bend their normal actions to fit their communication tools, rather than the reverse. Fortunately, the achievement of science in cheapening facilities, combined with its achievements in producing means for worldwide telephony, with consequent necessity of uniformity at the highest level and a revulsion against an intolerable situation, has now established a reasonably consistent criterion, to which most countries are working.

I have dwelt somewhat at length on these phases of telephony, partly to show the far-reaching effects of adherence to right or wrong concepts on the growth of an art and of the dominant influence of scientific research and engineering in establishing those right concepts; partly to emphasize a fundamental difference between the major aspects of telephony and telegraphy. Within relatively wide limits and except for special cases, there is no necessity for "no delay" service in telegraphy. Inside these limits, technical endeavor to cheapen the means of transport is little if at all influenced by elements of delay.

Distinctions between Two Modes of Transmission

With these considerations of philosophy behind us, a brief view of where the world stands in the year 1935 as regards the science and art at its disposal for telegraphy and telephony, and the use it is at present making of them, may be helpful.

In the matter of science and art, all forms of transmission of electrical energy, whether wire or radio, are potentially available for any and all forms of telegraphy and telephony.

Choice of transmission means in any given case, except to mobile terminals, is essentially a matter of costs, reliability, density and character of traffic. Broadly speaking, radio transmission is a non-secret broadcasting method of conveying intelligence, while wire transmission is a secret method confined narrowly to the terminals connected to the wire channels. In radio transmission, the number of non-interfering channels within any transmission range, though possibly large, is finite, while the number of wire channels is essentially infinite. Privacy in radio transmission can be obtained only in the special design of essentially complex terminal apparatus and can never be strictly secret. On the other hand, wire transmission (barring actual wire tapping) is essentially secret without selective design of terminal equipment. From its nature and the nature of the terminal equipment needed to "modulate" and "demodulate" the transmitted energy, radio transmission is essentially unadapted for services such as ordinary telephony where random connection between any of a very large number of terminals is involved. Wire transmission, on the other hand, is ideally suited to such service.

There are, of course, many minor considerations which influence determination of means in any given case, but broadly speaking, it is the major characteristics which bring about final decision. Neglecting special cases or cases of use which persist because of historical reasons in the commercial development of the art, present-day electrical communication in its major usages conforms to these major characteristics.

Wire transmission is indicated where privacy of communication between indicated terminals is required, where traffic density is high and maximum reliability of service is a prime desideratum, or where instantaneous switching between a large number of terminals is involved. In most of these cases, also, consideration of over-all costs weighs strongly in favor of wire transmission.

Radio transmission is indicated where broadcast dissemina-

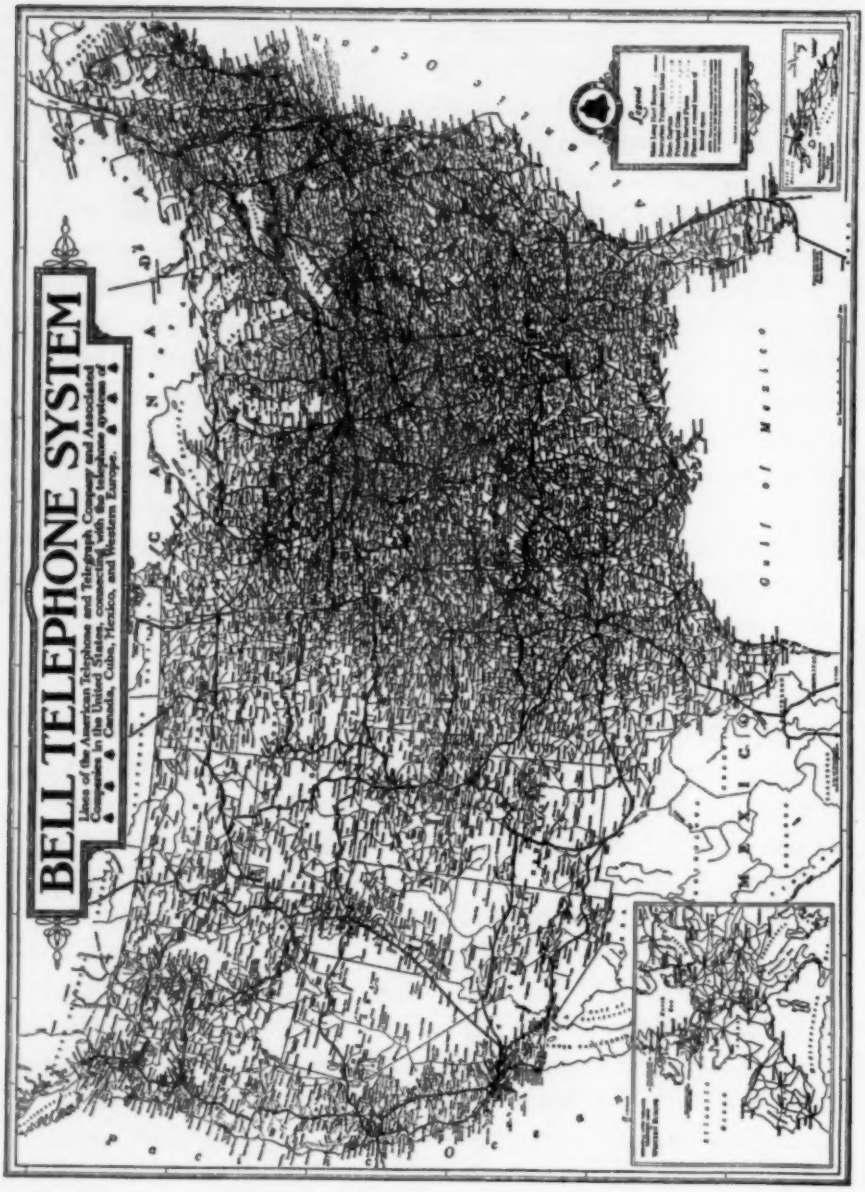

BELL TELEPHONE SYSTEM
Lines of the American Telephone and Telegraph Company and Associated Companies in the United States, connecting with the telephone systems of Canada, Cuba, Mexico, and Western Europe.
Gulf of Mexico

FIG. 1. THE BELL SYSTEM'S NETWORK OF TOLL AND LONG DISTANCE TELEPHONE LINES WHICH CRISSCROSSES THE UNITED STATES.

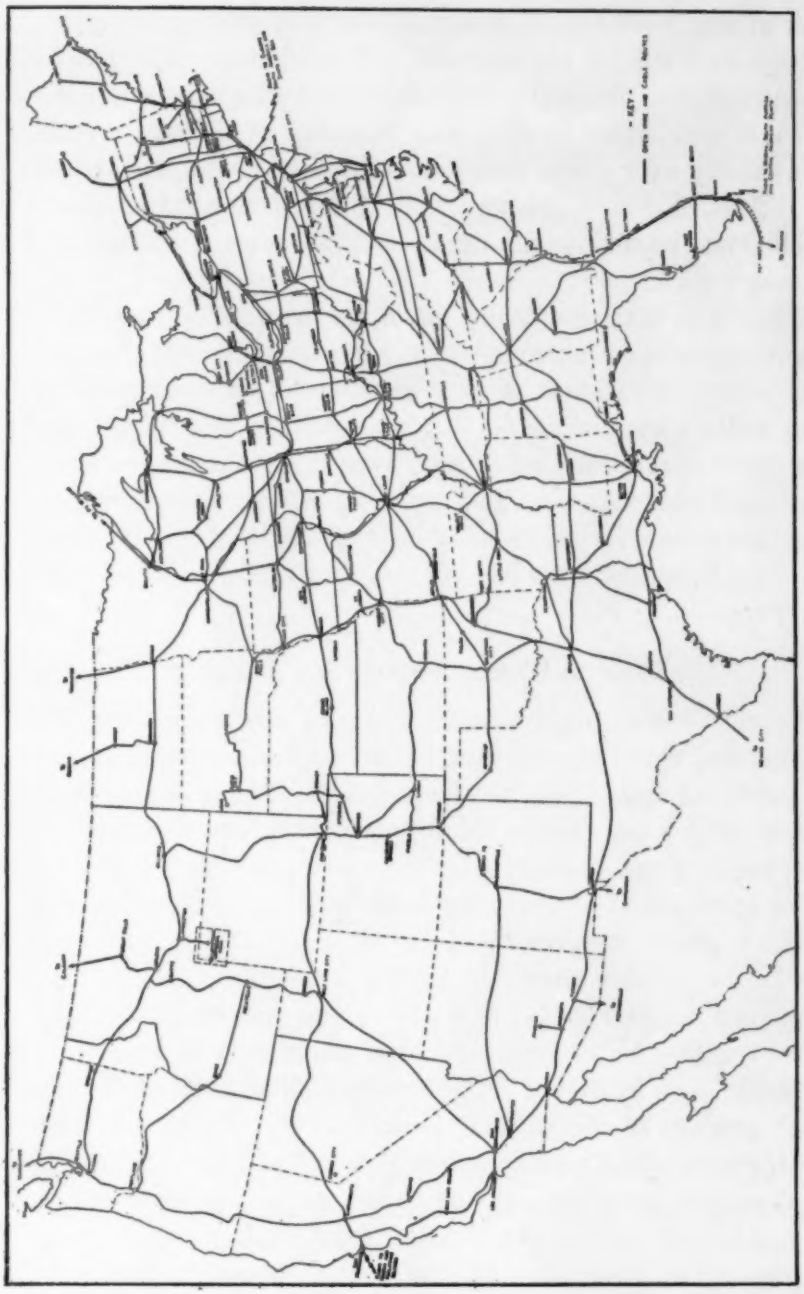


FIG. 2. CERTAIN LONG-HAUL ROUTES OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY.

tion of intelligence is desired and where reliability of service, though desirable, is not essential. It is likewise indicated for transmission to designated terminals where the intervening distance is over water or over long stretches of difficult terrain, particularly over routes where traffic density is low and irregular. It is, of course, uniquely indicated for the transmission of intelligence to mobile terminals, such as ships, airplanes and moving vehicles.

Thus it is that practically all of the world's ordinary telephone communication and the larger part of its regular telegraph communication is handled by means of wire transmission, with radio transmission playing an auxiliary and minor role. Per contra, practically all of a one-way dissemination of news, music and entertainment and much of ordinary telephony and telegraphy over very long low density traffic routes is provided by radio transmission, with wire transmission playing an auxiliary role.

A Service World-wide in Its Extent

To give you a simple visual picture of how completely our present-day world is gridironed by its communication channels, the following figures may be of assistance. I have chosen these merely to give you first an idea of the completeness with which the people of the United States have been provided with telephone service and of the main traffic arteries over which this service is given (Figures 1 and 2).

Likewise, I have shown in Figure 3 the the principal telephone arteries of Europe, in Figure 4 the principal radio telephone trunks which connect the principal telephone systems of the world, and in Figure 5 the principal submarine cable telegraph arteries of the world. Unfortunately, it did not seem feasible to prepare a chart showing the established radio telegraph routes, since these are obviously almost as numerous as the numbers of pairs of places where transmitting and receiving equipment is provided. In the main, however, the total

amount of telegraph traffic handled over the routes of this vast network is not great.

Obviously, also, it is not possible in a diagram of this kind

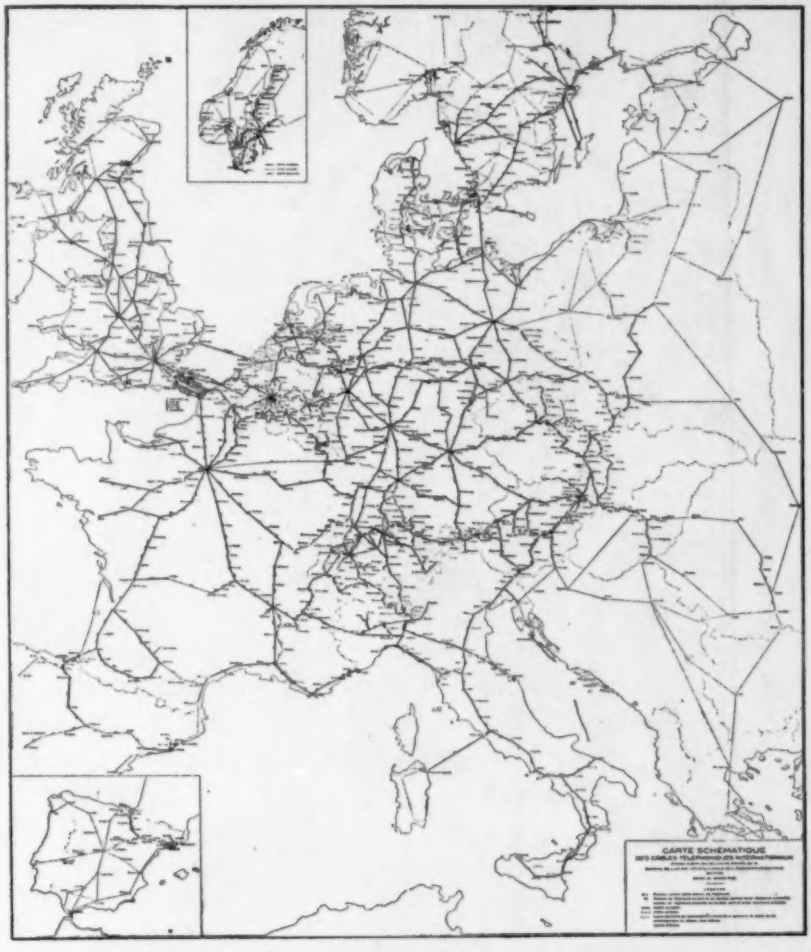


FIG. 3. THE TOLL TELEPHONE CABLE ARTERIES OF EUROPE.

to depict the situation of such a thing as radio broadcasting. Radio broadcast of news, music and entertainment is commonly thought of as primarily a utilization of radio transmission. So it is, in the transmission from the radio broadcasting station to

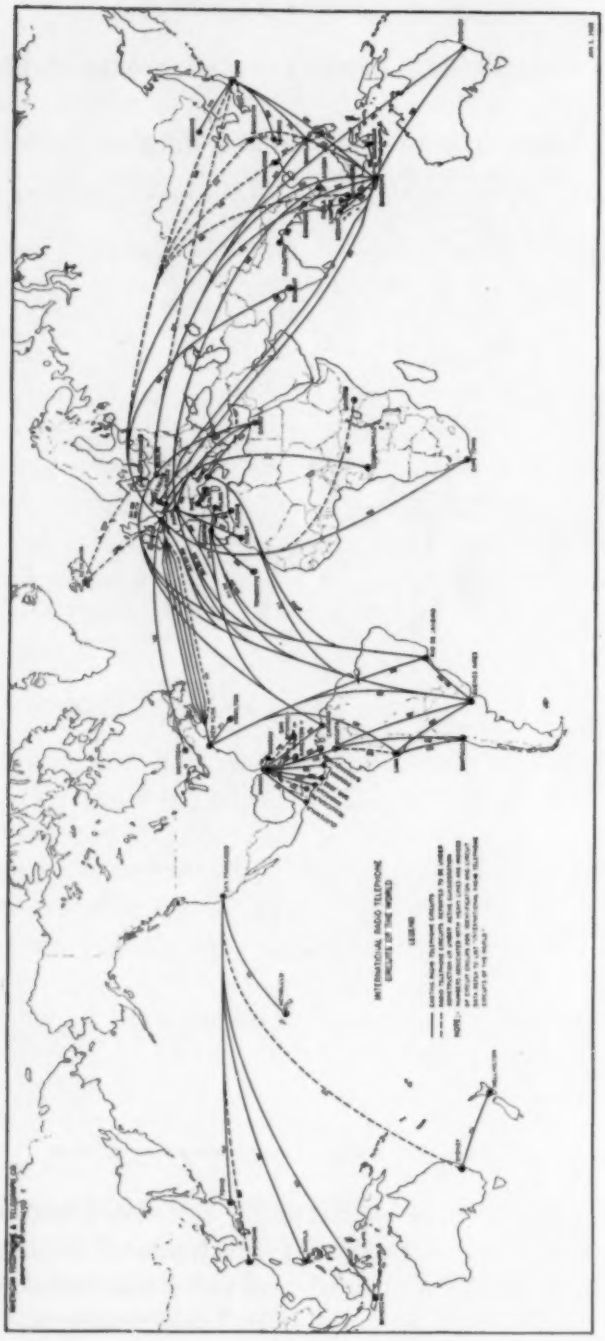


FIG. 4. THE PRINCIPAL RADIO TELEPHONE CIRCUITS OF THE WORLD.

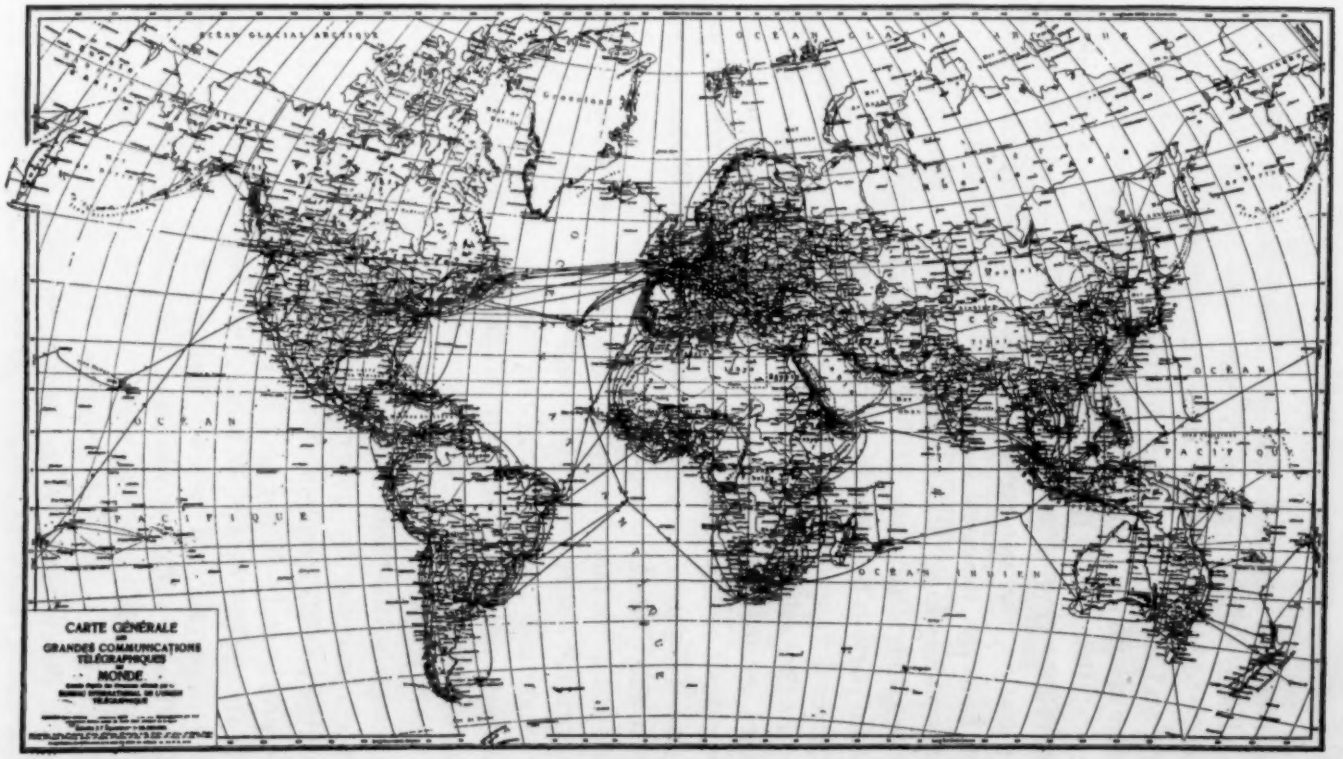


FIG. 5. THE PRINCIPAL SUBMARINE TELEGRAPH CABLES THROUGHOUT THE WORLD.

the numerous radio receiving sets which may be within the transmission radius. In every case, however, preceding the first stage of high frequency transformation at the broadcasting station and following the last stage at the radio receiving set it is wire telephony. In the simplest case of an isolated broadcasting station where the source material is from a studio at the station or from a terminal in the immediate neighborhood of the station, the amount of wire transmission may be small. When, however, we come to consider chain broadcasting, with many broadcasting stations connected to a common studio or other program source, the conditions are materially altered and the radio portion becomes in effect the terminal distribution of a large and frequently complex wire transmission network. Going further still, to the case where the program source is in a distant continent, the transmission channel to the final radiating broadcast stations is a combination of wire and radio transmission. (Figure 7 shows some of the wire broadcasting networks in the United States.)

Now just a few statistics, and the main outlines of the picture of our present situation will be complete.

In magnitude and importance in the field of electrical communication, ordinary telephony is the giant of the services. At the beginning of 1934 there were a total of approximately 32,500,000 telephones in use in the world. Of this number, approximately two-thirds were operated by private companies and the remainder by governments. Approximately 51 per cent of the world's telephones were in continental United States and approximately 56 per cent in North America. These figures in themselves do not, however, give any vivid idea of the relative importance of two-way telephony in the social and business life of different countries. A better figure for this purpose is to relate the number of telephones per hundred of population in the several countries (Figure 6). With this yardstick, development in the United States at the beginning of 1934 was 30 per cent higher than the corresponding figures

for New Zealand and Denmark and 40 per cent higher than that for Sweden, which outside of North America were the next highest. As will be seen from the chart, it was many

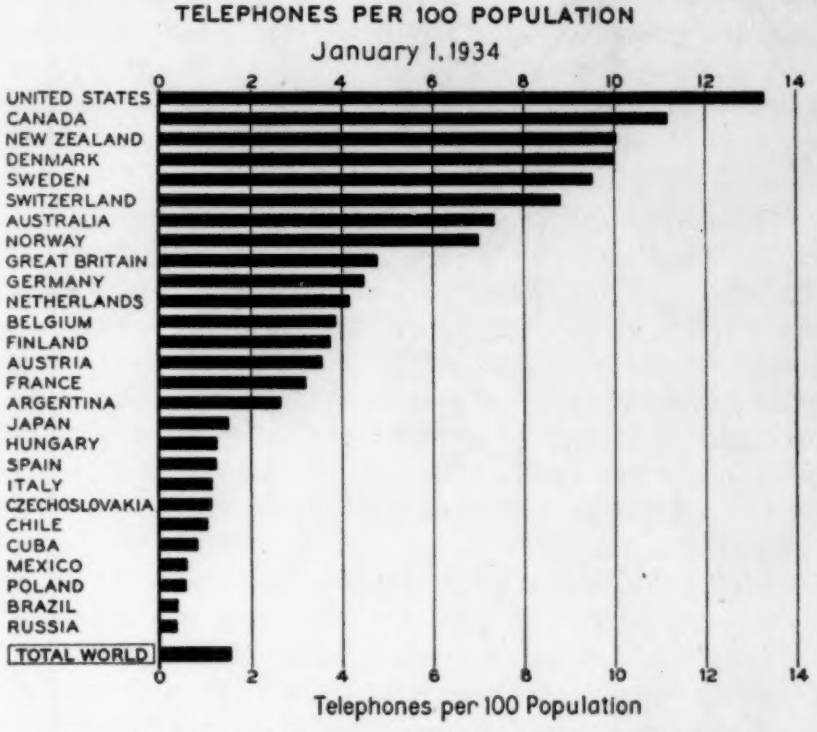


FIG. 6. TELEPHONE DEVELOPMENT OF THE NATIONS OF THE WORLD ON A POPULATION BASIS.

times the average of that for the civilized world outside the United States.

Another vivid illustration of the extent to which we in this country have gone in our adoption of the telephone is to point out that there are in the metropolitan area around New York City almost as many telephones in service as in all of Great Britain and Northern Ireland combined.

Illustrative of the fact that ordinary telephony is the giant of the regular communication services, is the fact that in 1933

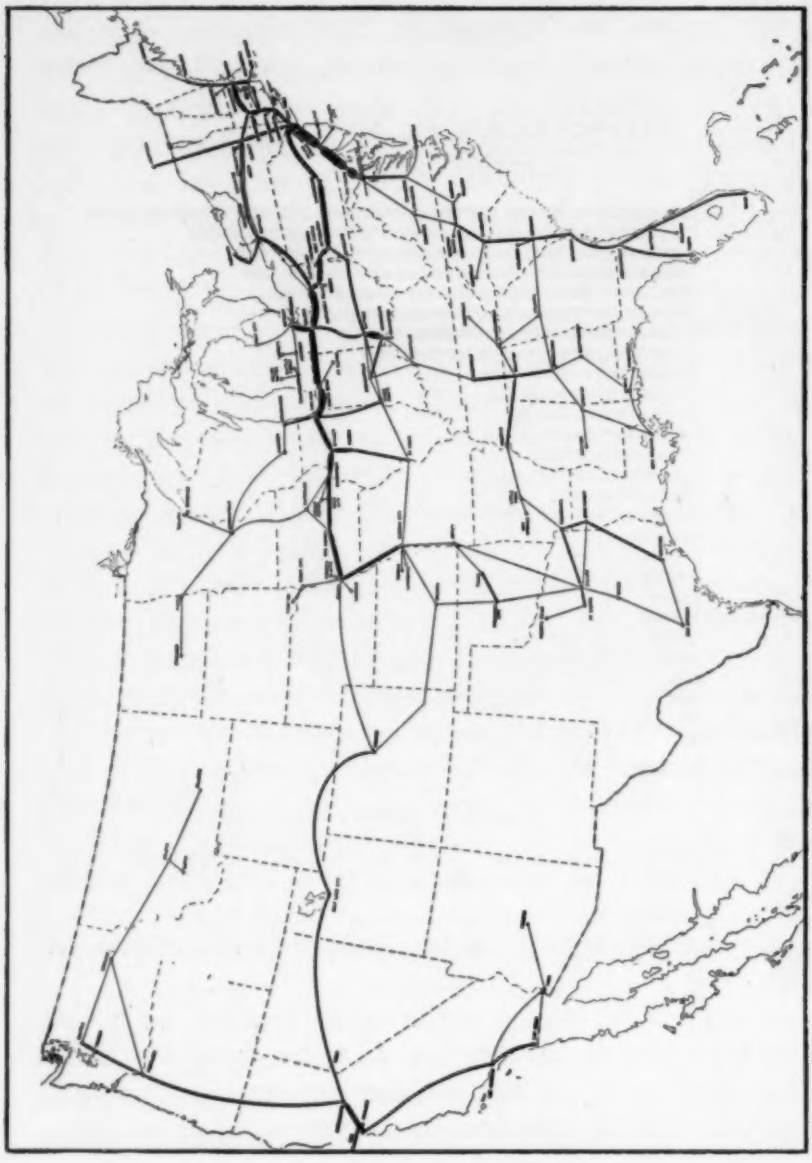


FIG. 7. SOME OF THE TELEPHONE TRANSMISSION LINES FOR CHAIN BROADCASTING IN THE UNITED STATES.

there were established in the United States a total of more than 24,000,000,000 telephone conversations and in the rest of the world approximately 21,000,000,000 conversations. Compared with this were totals of approximately 145,000,000 telegraph messages in the United States and 750,000,000 telegraph messages elsewhere. In other words, merely on a message basis comparison there were about fifty times as many transfers of intelligence through electrical means by telephony as by telegraphy.

Of the stupendous amount of radio broadcasting of news, music and entertainment which has developed in the last decade, there is of course no way of estimating in any units such as can be employed for ordinary telephony and telegraphy, nor is there any way of picturing the distribution of such broadcasts. Because it is broadcast in nature, each transmission can be picked up by anyone within the range of transmission. Numbers of broadcasting stations, probable numbers of radio receiving sets and approximate amounts of money involved we may know something about, but as to the magnitude of the traffic or as to its effects on society, we have no yardsticks. All we do know is that it has come to be a vast thing and that we are still in the experimental stage of its usage.

So much for the present; and now a word or two about the future as it appears to me. I say "as it appears to me" advisedly, because when it comes to dealing with the unknown future—even that of a narrow field—no two people are likely to have precisely identical views, even though they start from the base of a common understanding.

The Direction of Future Development

First, as to the general question which is frequently asked, as to whether one form or other of electrical communication may not develop such a dominance as practically to eliminate its competitor, it seems clear that the answer is "no." It is true that in the past fifty years telephony, because it was a newer

art, has developed much more rapidly than telegraphy and, in some sectors, at the expense of its rate of growth. It may and probably will continue, for some time to come, to grow more rapidly and possibly even in some directions at the expense of telegraphic growth. At the same time it is clear from past experience that whatever tends to facilitate interchange of intelligence tends to stimulate growth in all of the various means by which intelligence is transmitted. Added to this general tendency is the further fact that new forms of telegraphy, that is, forms of electrical transmission which are appraised through the eye, have come into the picture. Also, many of the scientific developments which are acting to advance the art of telephony are automatically benefiting the art of telegraphy by cheapening, simplifying and expediting its machinery.

If there is serious danger to telegraphy, it resides, I think, not so much in other forms of electrical communication as in entirely different methods of transporting the permanent records of which telegraphy is the electrical carrier. In brief, the principal danger, if there is one, would seem to lie in the realm of air transport. Unless, however, this danger is more real than I think it is, and unless telephony in one form or another develops to such an extent and produces such a revolutionary change in the methods of life as to eliminate necessity for the written record, there would appear to me to be no likelihood of telegraphy following the course of the ancient galley or of the sailing ship.

I have earlier mentioned that telephony and telegraphy have come to be parts of a common science and art where advances in one field may and frequently do find immediate application in the other. Since telephony is the more general case of electrical communication, it is natural not only that more of scientific attention should be paid to its problems but likewise that the greatest changes from the existing art are likely to result in it. There are, of course, some things which once done, remove completely the existence of a problem. For example, neither

in telegraphy nor in telephony will we ever again have to cope with the problem of overcoming distance. No matter how poorly we may be doing it at the present time, we nevertheless do know how to extend telephony and telegraphy between any two points on the earth's surface, and we are prepared to make this extension promptly if necessity arises. Likewise, we do know how to make substantially instantaneous connection between communication channels when these connections are desired in any random fashion.

Within these and similar limitations there is, however, still a great amount of research, development and practical application work to be done before we approach the limits of a completely comprehensive or completely adequate electrical communication service. Many of the things which we are now doing and will continue to do are done poorly when measured with the yardstick of what we know to be attainable or what we would consider to be wholly satisfactory. Vast though it is at present, electrical communication, and particularly telephony, is still far from being a universal service of maximum utility, even in a country as strongly telephone-minded as is the United States. How far the present is from an attainable future is evidenced by the figures quoted earlier as to present usage here and in the rest of the civilized world. Telephony is peculiarly an art in which the value of the service increases rapidly with the number of places and people who can be reached substantially instantaneously. We may never have occasion to want to communicate with some one at some distant point, but then again an occasion may arise where it is a matter of the utmost importance to be able to speak with some particular person at some particular spot and at a particular time.

Technically we seem about to enter a new era in the development of means for providing great numbers of transmitting channels economically for our longer distance routes. Through intensive research it has been possible to devise a simple form of cable and a means of transmission by which literally hun-

dreds of telephone channels can be obtained in a structure no larger than one's finger. Moreover, this structure is capable of transmitting the enormously wide frequency bands required in television—that newest of developments in telegraphy. This result marks the present stage of the advance which started twenty years ago as a result of the introduction of the vacuum tube and the electrical filter. Where the end of the road is, no man is wise enough to say. Nor is anyone wise enough to forecast what may be in store for us as we continue to find useful applications to electrical communication of the flood of new knowledge which continues to flow as a result of our delving further into the secrets of Nature.

In what I have said this evening, I have had in mind primarily electrical communication as an art. I have not had in mind those occasional transmissions of intelligence by electrical means which are not infrequently reported. When we read in the paper that Willie Smith in Brattleboro, Vermont, has conversed with Johnnie Jones in Sydney, Australia, using a home-made short wave radio set of small capacity, we are not considering electrical communication in the sense I have been considering it. Electrical communication, to be an art in the sense here under discussion, is much more than an occasional or fortuitous demonstration of scientific possibilities. It is a thing which must be available with a high degree of regularity to those who would use it. It requires for its giving, great co-ordinated service organizations. Unless it is regular and reliable, it may be useful on occasion but it can never influence largely the scheme of men's social and business intercourse. From a scientific and engineering standpoint it is apparent that our future course will result in structures and systems by which every form of electrical communication can be given over a plant which is largely interchangeable and readily adaptable to changing service requirements.

Since complete development of telephony hinges upon the production of physical things of very great efficiency, very low

cost and of extreme reliability, it is peculiarly a problem for science and engineering. We have already gone far enough in science and engineering to have a sufficiently accurate view of the future to be able to say with practical certainty that, given the opportunity, science and engineering can produce for society all of the communication tools it may need to extend electrical communication in any desired form as far as the normal requirements of society may dictate.

FRANK B. JEWETT

The Changing Years as Seen from the Switchboard

Editor's Note:

The interviews appearing under the above title in current employee magazines of the Bell System are reprinted here as affording an interesting supplement to "Opportunities for Women in the Bell System" which was published in the BELL TELEPHONE QUARTERLY *for January, 1932. Previous installments have appeared in the* QUARTERLY *for January and April, 1935.*

V. TRAINING METHODS—THEN AND NOW

Readers of the last installment of this series of interviews will recall that it closed with a question put to Miss Katherine Schmitt regarding methods used in training operators for their work when she began her career at the switchboard in New York in 1882.

"Well, in the very early days, we learned what we learned without a great deal of teaching," was her reply. "In going over this material which has been collected from the women who were operators, as I was, in the Eighties, you have noticed, I suppose, what they have to say about how they learned their part in the telephone business? Well, their training methods were just about like what we got—what I got when I went to work in the old Nassau office, in New York, fifty-three years ago."

It would be possible to select, at random, from the several hundred replies to the questionnaire sent to these pioneer operators, a description of training methods that would be typical of practically every central office in the country at the time. One of the most graphic of these descriptions is that by Mrs. Margaret Mackin Hyatt, of Chicago, whose words regarding the opportunities for women in the telephone business in its early days were quoted in a previous interview.

"Our training," says Mrs. Hyatt, "was brief and was about as follows: (She obviously quotes her instructor, whoever he or she may have been) 'This is the switchboard; this is a plug; and this is a jack. When a drop falls, you will plug into the jack directly under the drop and speak into this part of the telephone (it is called the transmitter) and put this part to your ear (it is called the receiver). You will give your number, which is 36, and the subscriber will give you either the name or number of the party he wants. If he gives you the name, look the number up in the directory, write both numbers on one of these tickets, and pass it to the operator directly behind you, who will complete the connection.'

"Unfortunately for me," Mrs. Hyatt adds, "the tone of voice to use was not mentioned, and as a result there was no doubt a startled subscriber when I yelled my number, and promptly received my first reprimand from an irate manager."

Almost invariably the new operators were seated beside more experienced girls and given headsets so that they could listen-in while the latter were at work. After a day or two of this, supplemented by such oral instructions as the older operators could give the recruits, the new girls were given a little operating to do during periods when the traffic was light. After an indefinite assignment at this part-time operating, they were informally graduated to full-time operating. That was substantially all the training that was given operators in the pioneer telephone days.

"Yes, that was about the way things were done in New York when I started work," comments Miss Schmitt. "It was all very informal—but it was also very personal, and when a new girl fell into the hands of an older operator who really took an interest in her, as was usually the case, she made remarkably rapid progress."

Telephone Service Becomes More Complex

As use of the telephone became more general and the amount of traffic increased, the problems involved in providing telephone service became more complex. These informal training methods became inadequate—partly because of the necessity of working more rapidly in order to keep abreast of the calls that came into the central offices, and partly because new apparatus was developed which could handle this increased traffic more efficiently, but which could do so only when the operators thoroughly understood how it was intended to function.

Many of the telephone companies issued printed or typewritten "Operating Rules" with which the girls were expected to familiarize themselves, and, in some cases, to learn by heart. Some of these, however, did not deal so much with operating practices as they did with the organization and discipline of the central office.

Perhaps the most important step toward more efficient work at the switchboard was the introduction of the present set-up of a chief operator and a number of supervisors in each office. The supervisors not only assisted the operators in their work, but actually continued their training, thus supplementing the preliminary instruction they had received. The use of supervisors did not become general throughout the Bell System until the late nineties or the beginning of the present century.

Another milestone along the road that has led to the high degree of operating efficiency which now characterizes Bell System central offices was the establishment of the first operators' training department by a telephone company—one of the pioneer steps in vocational training, which has become widespread, not only in the telephone service but in many other industries.

The First Training Course

Miss Katherine Schmitt was the first manager of this training department or school and, on the subject of this phase of

the training of telephone operators, speaks with an authority founded on long years of personal experience. Much of the information which follows is founded on her recollection of her training work, in which she was engaged as manager of this school, from 1902 to 1925, and as supervisor of training schools for the New York Telephone Company, from 1925 to 1930.

The need for such a training course, it would appear, had been felt for some time by the management of the Metropolitan Telephone and Telegraph Company (now the New York Telephone Company). The establishment of the school was, however, delayed until January, 1902, by which time the change from the magneto to the common battery switchboard had been completed in all central offices in New York City.

The theory on which this school was based closely followed that which was generally accepted in educational circles at the time. There was a definite emphasis on classroom work, to which practice on the switchboard was supplemental. The equipment of the school accordingly consisted of a room furnished after the manner of a typical school room, which was used for what amounted to lectures and for study periods, and an operating room. The latter duplicated as nearly as possible the equipment of an actual central office, with a twelve-position switchboard, a chief operator's desk, listening-in equipment, and so on. In addition to the manager and a chief operator, the staff consisted of a number of supervisors, all of whom were given preliminary training in their duties as instructors before the school was opened.

Routine of the course included presentation, in the classroom or at the switchboard, of the operating instruction to be learned for the day; follow-up instruction and practice at the switchboard, the supervisors putting through from their desks calls involving the particular points covered in the day's lesson; and considerable time spent in study in the classroom.

Within a relatively brief space of time, the establishment of this school in New York was followed by the opening of similar

training courses in Chicago, Philadelphia, Boston, Denver and elsewhere throughout the Bell System. The facilities for training provided in the smaller cities and towns were, of course, less elaborate than in the more populous centers, but their courses were based on substantially the same principle as those of the metropolitan areas. Many thousands of telephone operators have received their preliminary instruction in these courses.

New Educational Trends

While the development of these courses was under way, there had begun, in educational circles generally and in vocational education in particular, a trend toward a closer relationship between the preparation for a job and the job itself. Many a student, trained under the system in which emphasis was put primarily on classroom work, found great difficulty in passing through the period of transition from training to actual work. Many a telephone operator found that there was a vast degree of difference between a training course classroom or a practice switchboard and the job of handling a position in an actual central office—a difference which became the more marked as more emphasis was given to what may be called the school atmosphere.

To meet these difficulties, the training of telephone operators has moved into another phase—a phase which, in some particulars, is reminiscent of the old days when a new recruit learned her job by sitting at a switchboard and doing it, under the guidance of an older or more experienced operator. But the present system of training is not simply a return to the methods of pioneer days—it is such a return, plus all that it has been possible to learn about education and about the telephone business in half a century.

One of the best informed men in the Bell System on this phase of the training of telephone operators is Henry C. LaChance, of the Department of Operation and Engineering,

American Telephone and Telegraph Company. To him the writer went for some first-hand information on training methods now followed throughout the Bell System.

"Our training to-day," begins Mr. LaChance, "attempts to prepare the student actually to perform her specific job, and to give this preparation in a manner that is just as agreeable to her as we can make it, with a maximum of job atmosphere and a minimum of school atmosphere.

"You know," he continues, with a smile, "a lot of telephone operators—like a lot of other young women, and a lot of young men, for that matter—take a job because they are tired of going to school. Well, we have found that we can't successfully send a young woman like that to school when she applies for a job. What she wants is a job, and we try to make her feel that she has one. That's what I mean by 'a maximum of job atmosphere.'

Learning the Job on the Job

"On a girl's very first day with the telephone company, she is given a position on the switchboard at which she is to work. The rise and fall of traffic in all of our offices makes it possible to find positions which are not in actual use, so that they may be assigned to these new operators. At either side of the newcomer are experienced girls, busy with their work. The position to which she is assigned is identical with the others at the board and has, in addition, a key which protects the service against disturbance by practice calls.

"After the new operator has been seated at this position and given some informal instruction as to the handling of calls, a specially trained operator takes another position at the board—known as a 'control position'—from which she can simulate the calls that will have to be handled by the new operator when she is given an actual working position. Under the guidance of her instructor, the student operator sets up these calls, which are in every respect like actual calls. After she has become

proficient in this—and, incidentally, the training period is now considerably shorter than formerly—she is given an opportunity to handle actual calls during light traffic periods, and thus works into her job, almost without being aware of it.

"This process of 'learning by doing' is supplemented by discussion of operating practices and drills which may best be conducted away from the switchboard. Classes are held, but the groups of students are smaller than those in the training courses we formerly gave, and an effort is made to keep the atmosphere of these classes informal—in fact, we like to think of them as discussion groups, rather than as classes.

"The emphasis in our training work, however, is placed on practical training at the switchboard, rather than upon classroom work, though both are important. And both are designed to meet the requirements of the particular central office in which the operator is to work. The process of fitting the training to the job has been facilitated by a recent development which we consider most significant. This is a plan for analyzing the work which must be done by an operator in any particular office. In effect, the overall job is broken down into separate steps, so that the essentials of any operating job may be determined with scientific accuracy, whereas formerly this was attempted on a basis of judgment. The result has been a much closer adjustment of the training effort to the actual job in each case. Today, our people take it for granted that the first step in formulating a training plan is to find out what the job really is—not as written in a book but as actually performed at the switchboard.

"I cannot emphasize too strongly the advantages of carrying on this training, as we now do, right in the central office where the operator is to work when her training is completed. From her very first day, she becomes accustomed to the atmosphere of this particular office, and becomes a part of it. As all telephone people know, traffic conditions and service requirements vary widely in different central offices. Under our present sys-

tem, the training in each office is particularly suited to the requirements of that office, as determined by the analysis to which I just referred.

"Training is Never Finished"

"Moreover, we make a point of continuing the training, even after a girl has been given actual traffic to handle. A moment ago, I used the expression 'after her training is completed.' I'd like to correct that—you see, an operator's training is never finished. One of our objectives is to give her the opportunity of always learning to do her work better. Having the preliminary training done in the office where she is to work makes this continuation of her training much simpler. The opportunity for self-improvement doesn't involve 'going back to school' or taking what might be called 'post-graduate' courses. Rather, it consists in seeking and receiving assistance from a competent supervisor in learning the refinements of the job while working at it. In other words, the operator's job and her training for it have been brought so closely together that the two are, in effect, parts of the same activity."

These words of Mr. LaChance—this idea of bringing the job and the training for it as closely together as possible—come near to summing up the whole philosophy of the Bell System's training of its employees, operators among them. Methods change—including training methods—but purposes remain constant. To give the best possible service at the lowest possible cost is the first and most fundamental of the purposes which lie behind Bell System methods. Whatever may be the training methods of the future, this much is certain about them: they will be directed toward the single objective of helping the telephone operator to do her work in the best possible way.

VI. A Sound Mind in a Sound Body

"A sound mind in a sound body," wrote a Roman poet, nearly nineteen hundred years ago, "is a thing to be prayed

for." Hardly more than a century before this, in Galilee, another principle had been proclaimed: "All things whatsoever ye would that men should do to you, do ye even so to them."

Generations came and went, each quoting these two sayings separately, apparently without dreaming that they might be related. Individuals prayed for, and sought in other ways to find—for themselves—the much to be desired combination of mental and bodily health which Juvenal had commended. It seems almost never to have occurred to them that one form of applying the Golden Rule was to seek a sound mind in a sound body for others.

Specifically, it rarely occurred to an employer that there might rest upon him an obligation, other than that of self-interest, to care for the health of his employees. While Rome held sway, most of the world's work was done by slaves; throughout the age of feudalism, it was done by serfs who were little better than chattels. Long centuries elapsed before employers learned that proper care for the health of their employees was both good business and good morals. Even after this fact had been fairly well accepted, many years passed before any real progress was made in the direction of promoting the health of workers.

A Business Newly Created

Sixty years ago, when the telephone was born, the movement toward more wholesome and healthful conditions for employees in industry and business was still looked upon as an innovation. Even in long established enterprises, only a few forward-looking employers were taking serious thought as to the health of their personnel. And here was a business that had been but newly created, and was facing the problems that are common to all new businesses. They were tremendously preoccupied, those pioneers of the first decades of telephone history, in doing the thousand and one things that had to be done in order to make Bell's invention work satisfactorily. It would have been

small wonder if they had come to the conclusion that, with a multitude of seemingly more important things crying out for attention, they had scant time to think of the health of their employees.

And yet the evidence is clear that these men who, in those busy pioneering days, laid the foundations of the Bell System, laid also the foundation for what might be called the Bell System's philosophy or unwritten policy regarding the provision of wholesome working conditions for its employees, and for its present activities which are directed toward helping the employees to take an intelligent interest in their own health. This philosophy, and the means for its practical application, did not come into existence full-grown. They have been the results of a long process of evolution, as has every other useful thing in the telephone business. Yet the initial steps in this evolution were taken in those first telephone years, more than half a century ago.

Few men are more familiar with the fundamentals of this philosophy than Dr. C. H. Watson and Charles J. Schaefer, Jr., of the Benefit and Medical Department, American Telephone and Telegraph Company. On this subject both men speak with authority, Dr. Watson primarily from the standpoint of the medical man and Mr. Schaefer from that of one who has had wide experience in solving the administrative problems arising from the application of this policy to the requirements of the widely separated territories of the Bell System as a whole.

Inseparable Obligations

"It is a significant fact," Dr. Watson began, "that the development of telephone service, at its very inception, fell into the hands of men who had not only high ideals as to the obligation to the public which the provision of such a service carried with it, but who clearly saw that this obligation was inseparable from the responsibility of taking a personal interest in the welfare of their employees.

"This interest was, I think, originally only what that word implies. It was probably not even a definitely formed point of view. Rather, these telephone pioneers took an unconscious interest in their employees because it was natural for them to do so—they were that kind of men. Precedent crystallized this interest into a point of view, and the point of view, in turn, into a generally accepted philosophy. By a process of evolution, this philosophy eventually became a definite part of the Bell System's fundamental policy of providing for the public 'the most telephone service and the best.'

"In our health activities our interest is directed, as it should be, primarily toward the welfare of our employees. Secondarily it is directed toward the public, and the kind of service we provide for that public. In a very true sense, the welfare of employees and the quality of service are directly related. Put an operator, with a number of other operators, into a room that is inadequately lighted or improperly ventilated and heated, and see what would happen to your service. Or try giving the type of service we give now, without the provision of wholesome and attractive rest and recreation rooms or places in which the operators may have their meals. Or discard what we are doing along the line of giving medical advice or assistance when required. Or abandon our health education activities. You will find that our philosophy as to the physical wellbeing of our employees is definitely a part of our policy of providing the best possible service."

An Operating Room in 1883

The progress made in the practical application of the Bell System's philosophy as to the welfare of its employees—and particularly of its operators—may, perhaps, best be shown by contrasting conditions in the typical operating room of a modern central office with those in equally typical central offices of a half a century ago. Here, for example, is a bit of description

from the pen of Miss Frances Oberbeck, who tells of the office in which she went to work as an operator in St. Louis in 1883:

The office was located on the second floor of a three-story brick building which had been built for a store. The Telephone Company floor was divided into three rooms. The front room, which was the largest, was the operating room. It was heated by an old iron stove and lighted by a bracket of coal oil lamps suspended from the switchboard. This old stove was one which invariably needed cleaning on the coldest days of winter. Our chief operator would rake out the hot coals on a big sheet of tin, open wide all the windows so as to blow out the smoke, and clean the stove while we poor operators sat shivering at the switchboard, trying to establish connections.

The middle room was the rest room. There was no ventilation except what came through from the operating room, and it was poorly lighted by a coal oil lamp suspended from the ceiling. The furnishings were most scanty. There was a long table where we ate our lunch, which we carried to work with us, a few chairs and a row of hooks upon which we hung our hats and coats.

In Massachusetts, where the telephone was born and where, presumably, its development had gone farther, the physical conditions under which the operators worked were hardly less primitive. Miss Grace G. Hollis writes of an office in Somerville, as it was in 1885, in these words:

The office at that time was located in a wooden building over a drug store. The company quarters included an operating room, a small office for the superintendent, and a stock room in the corner in which a wash room was located. Gas was used for lighting the rooms and a parlor stove provided heat. The night operator brought in enough wood and coal to keep the fire during the day, but in real cold weather the girls carried additional coal when necessary. The floors were uncovered and all washing, cleaning and general janitor work was done by the operators.

When Lunch Time Came

Another contrast, hardly less striking and significant, may be afforded by comparing a modern telephone company lunch room with the facilities, or the lack of them, with which the operators of pioneer days seem to have philosophically con-

tented themselves. Miss Augusta Greenslade, who began work as an operator in New York in 1892, gives this graphic description of some of the disadvantages which attended the lunch hour in her particular office:

> On my first day when I went to lunch I found that the mice had eaten half of what I had brought from home. Being young and always ready to eat, and not having money to buy another lunch, I finished what the mice had left. Thereafter I carried my lunch in a tin box. It was not considered dignified to carry your lunch, so I carried my tin box in a black satin bag.

An Evolution Under Way

Even at the time when conditions like this continued to exist in some places, there is evidence that the evolution toward present-day health policies was under way in others. Here and there a few central office managers began the practice of providing for the services of a matron, who came in each day to prepare tea, coffee or hot water, or to lend a helpful hand to any operator who might be ill. In certain offices, in the Eighties and Nineties, it was the custom to supply free coffee, cocoa, bread, butter and fruit for the operators' lunches. A lunchroom based on the cafeteria principle was opened as early as 1895. By about the end of the first decade of the present century, most of the companies were providing dining service in their principal cities. From this point on, the development of the attractive, comfortable and carefully supervised dining room in the typical telephone office of the present day has been a process of gradual but steady growth.

A similar process of growth from small beginnings has taken place with regard to the provision of medical facilities by the Bell System companies for their employees. A most elementary form of providing medical treatment was that which some managers adopted, apparently at an early period of telephone history. In cases of illness or minor accident, a boy was dispatched to the nearest drug store, with a modest sum provided out of company funds, to buy such medicines or simple drugs

as a layman's diagnosis seemed to indicate were required to meet the situation.

Another step forward was the emergency cabinet with which all but the smallest central offices were later provided. These were kept supplied with a moderate assortment of simple remedies for minor illnesses.

If an operator was more seriously ill, she was sent home and advised to consult her family physician, or a doctor was summoned. Here, incidentally, is one of the fundamentals of the Bell System's health policy, as Dr. Watson specifically points out.

Not Substitute for Private Physician

"Our medical work," says he, "never was and is not now intended to take the place of the services of the employee's private physician. Sometimes our work is quite simple in its nature, as it was everywhere in the early days, and as it has to be in some localities even today. Sometimes it is more extensive, as it is in many of our Associated Company headquarters buildings, where we have many hundreds of employees. In either case, our medical activity goes no further in the direction of treatment than the provision of relatively simple remedies in emergency cases, where the services of a family physician are not required, or of rendering temporary treatment to tide a patient over until his or her physician can be consulted. One of the most important services we perform lies in the direction of diagnosis and advice, in which we are often able to coöperate closely with the employee's private physician.

"Our medical work has, of course, made another important contribution to the welfare of the employees. I refer to the physical examinations which prospective employees are given when applying for positions. These are important, not alone from the standpoint of keeping the physical condition of our personnel up to a high standard, but for the purpose of enabling

us to place each new employee in the position for which he or she is best fitted, mentally and physically, and in which, therefore, he or she can best take advantage of the opportunities for advancement afforded in telephone work.

"In short, our medical activities are directed toward the objective of getting employees who are fitted for the work to which they are assigned, and helping to keep them fit, mentally and physically, to do that work as well as it can be done. That is our part of the job of giving the public the best possible telephone service the Bell System can provide."

An important step in the development of the Bell System's health policy was the establishment, in 1913, of the Employees' Benefit Plan, by means of which, in addition to other classes of benefits and pensions, provision is made for the financial care of employees during illness, through a continuation, for specified periods, of full pay and half pay. This plan was likewise the result of a process of evolution. Quite early in telephone history, practices were followed in certain places which provided some financial aid to employees during illness. However, such practices, where they were in effect, differed with respect to amounts and periods of payments in the various Associated Companies. With the adoption of the Employees Benefit Plan, this financial care of employees during illness and certain other emergencies became systematic and was placed on a uniform basis throughout the Bell System. In the administration of this plan, the medical activities of the American Telephone and Telegraph Company and the Associated Companies play an important part.

"An Ounce of Prevention"

It has been said, so many times that the expression has become a household adage, that "an ounce of prevention is worth a pound of cure." This principle forms an inherent and essential part of the Bell System's policy as to the health of its employees. Like other phases of telephone development, this

preventive health work has been a growth from small beginnings. In many cities the principle of "an ounce of prevention" was put into practical effect many years ago by managers who made it a practice to keep on hand in each central office a supply of dry stockings and slippers to be used by operators who came to work with wet feet. Rubbers and umbrellas were also supplied for the use of those who were faced with the problem of getting home through an unexpected shower. Now, in all but the smaller places, each operator has an individual locker, in which she can keep her own supply of such articles.

One of the most practical forms of preventing disease and illness due to accident is education. Largely out of the Bell System's educational work in accident prevention and first aid training, at first confined to its male employees, has grown another branch of instruction designed particularly for women—the Health Course.

Prior to 1925 a considerable amount of experimental work in health education had been done by several Bell System Companies, including the New York Telephone Company and the Bell Telephone Company of Pennsylvania. Mr. Schaefer participated in the development of the health courses given to its women employees by the latter company. In 1925 he was transferred to the American Telephone and Telegraph Company, at the suggestion of the late Edward K. Hall, then Vice President in charge of personnel matters, and asked to assist in organizing a health course for women throughout the Bell System. He has been engaged since then in this and the other phases of the work of the Benefit and Medical Department of the American Company, and speaks out of wide experience.

Facts, Not Fads or Fancies

"Advice on health," says Mr. Schaefer, in commenting on the fundamental reasons for the establishment of the course, "is one of the easiest things in the world to obtain. The trouble is that the advice which one receives is sometimes so heavily

tinctured with theory or with outright mistakes or misstatements that it is untrustworthy. To follow it may prove positively harmful.

"At the time this course was established, there was, as there still is, a definite demand on the part of telephone women for health information in which they could have absolute confidence. They wanted facts separated from fads and fancies. Our course was designed to meet this demand. It provided instruction in emergency care of minor illnesses and injuries, the principles of hygiene and the elements of the care of the sick in the home. We were not and we are not now trying to turn out the equivalent of professional nurses, so far as the care of the sick is concerned. It is merely intended, with respect to this part of the course, to fit telephone women to do the simple home nursing, which under any conditions many of them may be called upon to do at some time or other, a little more capably than they could do it without this training."

The Health Course Grows

During its first year, more than 17,000 telephone women were enrolled in the Health Course, of whom more than 14,000 were graduated. In the second year, more than 45,000 were enrolled, of whom more than seventy-four per cent completed the course. Since the course was established, more than 149,000 women have been graduated. Of these, many have continued their studies by taking advanced courses in first aid treatment and nutrition, the graduates of the latter course now numbering more than 7,000.

"In the preparation and development of the Health Course, and of all of our health activities," says Mr. Schaefer, "we have had the valuable advice and active participation of our associates in the operating departments here at headquarters and in the Associated Companies. I am sure that Dr. L. D. Bristol, our Health Director, who is now in charge of health educational work, recognizes, as we have in the past, the im-

portant assistance given us by these representatives of other departments. I am certain, too, that he will agree with me that a tribute is due to the women of all ranks of the organization who have participated so wholeheartedly in the work, and made so many sound suggestions for its improvement."

Among the multitude of changes brought by the passing years, few have contributed more importantly to the improvement of telephone service than those which have had to do with the health of employees. This has been particularly true as applied to the women at the switchboard. The gradual growth of the Bell System's interest in the health of its employees and the evolution of means for the practical application of this interest have been integral parts of the evolution of telephone service itself—steps in the steady advance toward the objective of the best telephone service that it is humanly possible to provide, at the lowest possible cost.

R. T. BARRETT

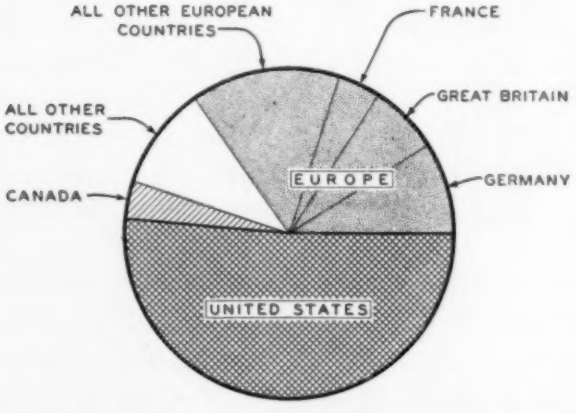
(To be concluded)

The World's Telephone Statistics

January 1, 1934

AS the years go by, the telephone becomes more and more firmly established as an invaluable instrumentality of economic and social welfare. Although telephone facilities are much more extensive in the United States than elsewhere, the annual surveys of telephone growth and development throughout the world undertaken by the Chief Statistician of the American Telephone and Telegraph Company show an unmistakable trend towards greater telephone usage in every country. The results of the latest survey have recently been published in a pamphlet entitled "Telephone and Telegraph Statistics of the World, January 1, 1934." The figures and charts in this article have been taken from that pamphlet.

DISTRIBUTION OF THE WORLD'S TELEPHONES
January 1, 1934

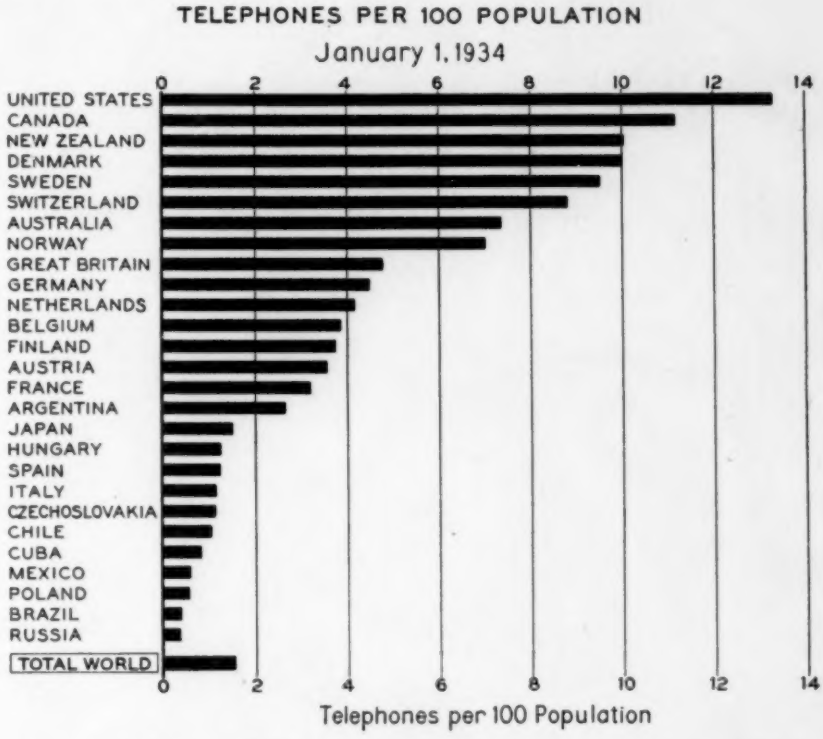


There were 32,495,855 telephones in the world on January 1, 1934. Of these, 16,710,858, or 51.4 per cent, were in the United States. This number was almost 50 per cent greater

than the number of telephones (11,306,955) in all of Europe, although Europe has a population four and a half times that of this country. The remaining 4,478,042 telephones were distributed among the countries outside the United States and Europe.

Comparative Telephone Development of Countries

The table, "Telephone Development of the World, by Coun-



tries," presents data for individual countries of the world in respect of telephone density, conventionally measured by the number of telephones in relation to each 100 of the population. The supremacy of the United States in point of telephone development remains undisputed, this country having 13.29 telephones per 100 population. The Dominion of

TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES

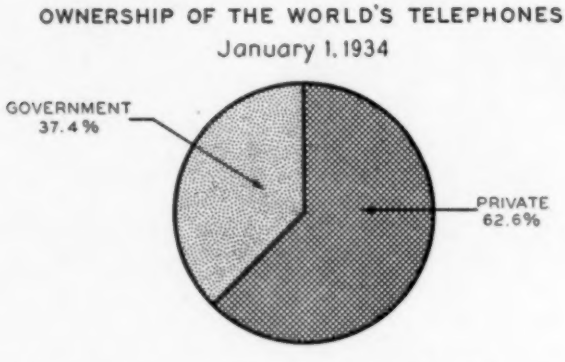
January 1, 1934

Countries	Number of Telephones			Percent of Total World	Telephones Per 100 Population
	Government Systems	Private Companies	Total		
NORTH AMERICA:					
United States	—	16,710,858	16,710,858	51.42%	13.29
Canada	193,641	998,689	1,192,330	3.67%	11.15
Central America	12,137	14,020	26,157	.08%	0.39
Mexico	1,337	99,871	101,208	.31%	0.59
West Indies:					
Cuba	485	32,355	32,840	.10%	0.81
Porto Rico	537	11,209	11,746	.04%	0.71
Other W. I. Places	7,044	14,135	21,179	.07%	0.32
Other No. Am. Places	—	11,032	11,032	.03%	3.02
Total	215,181	17,892,169	18,107,350	55.72%	10.38
EUROPE:					
Austria	239,870	—	239,870	.74%	3.55
Belgium**	317,217	—	317,217	.98%	3.86
Bulgaria	20,276	—	20,276	.06%	0.33
Czechoslovakia	149,296	19,878	169,174	.52%	1.12
Denmark#	16,289	348,438	364,727	1.12%	9.99
Finland	1,658	138,000	139,658	.43%	3.74
France	1,349,520	—	1,349,520	4.15%	3.19
Germany#	2,953,614	—	2,953,614	9.09%	4.48
Great Britain and No. Ireland	2,226,329	—	2,226,329	6.85%	4.78
Greece	—	20,356	20,356	.06%	0.31
Hungary	110,430	727	111,157	.34%	1.25
Irish Free State#	33,450	—	33,450	.10%	1.11
Italy*	—	482,507	482,507	1.48%	1.13
Jugo-Slavia	46,006	1,209	47,215	.15%	0.33
Latvia#	62,174	—	62,174	.19%	3.19
Netherlands	343,177	—	343,177	1.06%	4.14
Norway*	121,376	78,400	199,776	.61%	7.00
Poland	100,839	88,366	189,205	.58%	0.57
Portugal	11,500	35,706	47,206	.15%	0.68
Roumania	—	51,613	51,613	.16%	0.28
Russia¶	576,332	—	576,332	1.77%	0.35
Spain	—	290,829	290,829	.90%	1.24
Sweden	589,394	1,520	590,914	1.82%	9.51
Switzerland	363,655	—	363,655	1.12%	8.81
Other Places in Europe	104,308	12,696	117,004	.36%	1.41
Total	9,736,710	1,570,245	11,306,955	34.79%	2.02

SOUTH AMERICA:					
Argentina	—	312,086	312,086	.96%	2.64
Bolivia	—	2,000	2,000	.01%	0.06
Brazil	1,041	169,764	170,805	.53%	0.38
Chile	—	46,159	46,159	.14%	1.04
Colombia	2,500	27,425	29,925	.09%	0.32
Ecuador	3,010	2,730	5,740	.02%	0.23
Paraguay	—	2,499	2,499	.01%	0.28
Peru	—	17,200	17,200	.05%	0.27
Uruguay	—	42,707	42,707	.13%	2.14
Venezuela	600	19,390	19,990	.06%	0.61
Other So. Am. Places	2,808	—	2,808	.01%	0.52
Total	9,959	641,960	651,919	2.01%	0.71
ASIA:					
British India#	22,804	35,437	58,241	.18%	0.02
China	72,000	82,000	154,000	.47%	0.03
Japan#	1,015,372	—	1,015,372	3.13%	1.50
Other Places in Asia	132,669	60,257	192,926	.59%	0.12
Total	1,242,845	177,694	1,420,539	4.37%	0.14
AFRICA:					
Egypt	46,888	—	46,888	.15%	0.22
Union of South Africa#	126,608	—	126,608	.39%	1.50
Other Places in Africa	96,317	1,813	98,130	.30%	0.09
Total	269,813	1,813	271,626	.84%	0.18
OCEANIA:					
Australia*	487,662	—	487,662	1.50%	7.35
Dutch East Indies	38,267	3,663	41,930	.13%	0.06
Hawaii	—	23,111	23,111	.07%	5.78
New Zealand#	155,059	—	155,059	.48%	10.01
Philippine Islands	6,000	20,182	26,182	.08%	0.19
Other Places in Oceania	3,294	228	3,522	.01%	0.15
Total	690,282	47,184	737,466	2.27%	0.81
TOTAL WORLD	12,164,790	20,331,065	32,495,855§	100.00%	1.54

* June 30, 1933.
** February 28, 1934.
\# March 31, 1934.
¶ U.S.S.R., including Siberia and Associated Republics.
§ Includes approximately 14,300,000 automatic or "Dial" telephones, of which about 46% are in the United States.

Canada continues in second position with 11.15, New Zealand is third (10.01), Denmark fourth (9.99), and Sweden fifth (9.51). In regard to the major European countries, Great Britain, with a development of 4.78, ranks tenth; Germany, which has 2,953,614 telephones and is second to the United States in absolute number of instruments, ranks eleventh as regards telephones per 100 population (4.48); while France ranks sixteenth, with 3.19. Japan, with a little over one million telephones, is the outstanding telephone country in Asia, although its development of only one and one-half telephones for each 100 of its people is well below that of the larger Occidental



countries. Argentina, with a telephone development of 2.64, leads all other South American countries.

Of the total number of telephones in the world, 62.6 per cent are in systems which are owned and operated by private companies. The achievement of the private companies in the United States, the best developed country in the world telephonically, is well known. In Canada, the next best developed country, 84 per cent of the telephones are under private ownership and management. Denmark ranks fourth in respect of telephone development and over 95 per cent of its telephones are owned and operated by private companies. In striking contrast to these countries are the three major European nations, Great Britain, Germany, and France, where the tele-

TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES

January 1, 1934

Country	Service Operated by (See Note)	Number of Telephones		Telephones per 100 Population	
		In Communities of 50,000 Population and Over	In Communities of less than 50,000 Population	In Communities of 50,000 Population and Over	In Communities of less than 50,000 Population
Australia*	G.	279,700	207,962	8.71	6.08
Austria	G.	178,802	61,068	8.13	1.34
Belgium**	G.	221,621	95,596	6.33	2.03
Canada	P. G.	647,000	545,330	19.33	7.43
Czechoslovakia	P. G.	69,133	100,041	4.04	0.75
Denmark	P.	181,822	180,778	19.24	6.72
Finland†	P.	50,151	84,500	10.49	2.61
France	G.	734,401	615,119	8.31	1.84
Germany#	G.	1,897,458	1,056,156	7.12	2.69
Great Britain and No. Ireland#	G.	1,618,500	646,700	6.17	3.18
Hungary	G.	84,636	26,521	4.14	0.39
Japan#	G.	656,752	358,620	3.41	0.74
Netherlands	G.	224,604	118,573	6.65	2.41
New Zealand#	G.	61,486	93,573	11.34	9.29
Norway*	P. G.	76,461	123,315	18.88	5.03
Poland	P. G.	111,102	78,103	2.29	0.28
Spain	P.	177,601	113,228	3.54	0.62
Sweden	G.	231,996	358,918	22.59	6.92
Switzerland	G.	163,961	199,694	18.82	6.13
Union of South Africa	G.	69,451	57,157	6.77	0.77
United States	P.	9,386,321	7,324,537	18.54	9.76

Note: P. indicates that the telephone service is wholly or predominantly operated by private companies, G. wholly or predominantly by the Government, and P. G. by both private companies and the Government. See first table.

† January 1, 1933.
* June 30, 1933.
** February 28, 1934.
\# March 31, 1934.

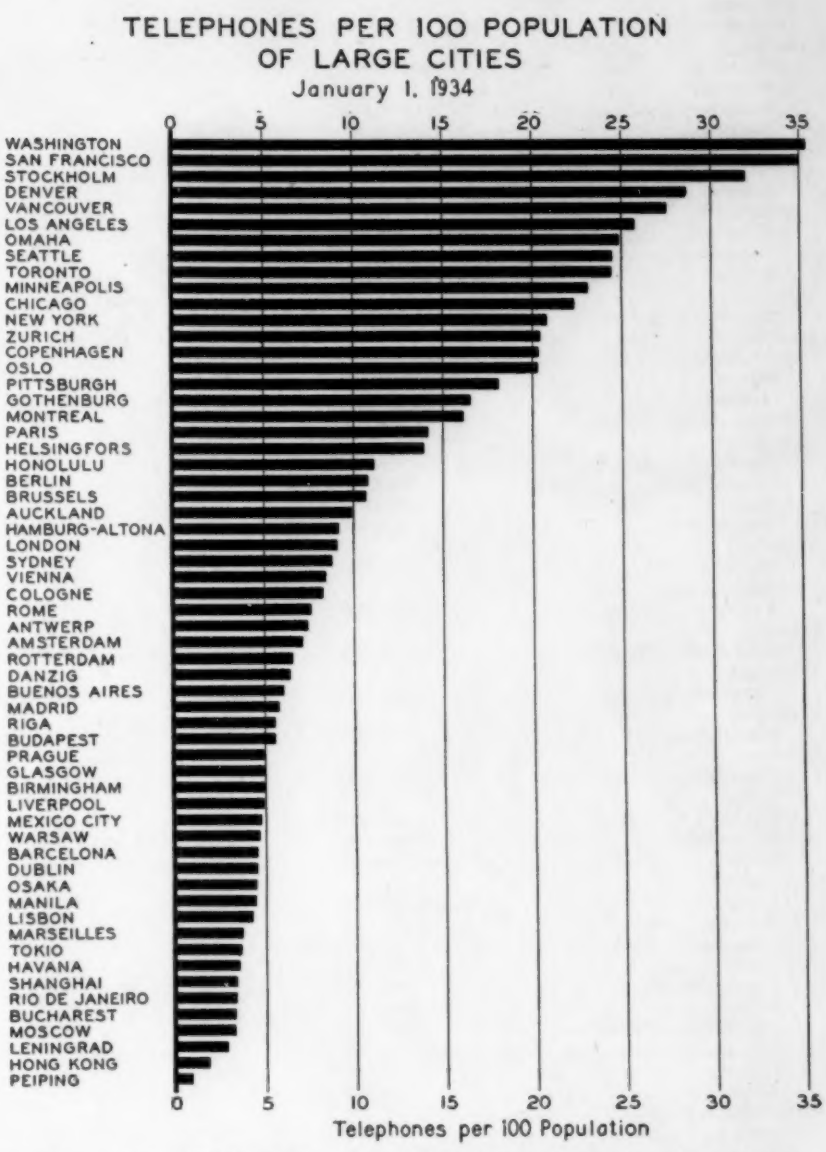
phone service is operated exclusively by the government and which rank tenth, eleventh, and sixteenth, respectively, as regards telephone development.

Telephones in Large and Small Communities

Telephone development is not only higher, but is more widely distributed, in the United States than in other countries. The table "Telephone Development of Large and Small Communities" gives some indication of this fact. It will be observed that in the smaller communities—those with less than 50,000 inhabitants—the United States averaged 9.76 telephones per 100 population. This not only exceeds the development of the smaller communities in all other countries, but reflects a considerably better telephone development of these communities in this country than the development of all but three foreign countries *as a whole*. Compared to these American standards, telephone facilities in the smaller towns and rural areas abroad are generally exceedingly limited: in Great Britain, there were only 3.18 telephones per 100 population in the smaller communities, in Germany 2.69, and in France 1.84.

Telephones in Large Cities

Among the large cities of the world, Washington, D. C., leads in respect of telephone development, with 35.31 telephones per 100 population. San Francisco is second, with a development of 35.00. As a matter of fact, except for the Swedish city of Stockholm, which has a development of 31.95, and the two Canadian cities of Vancouver (27.51) and Toronto (24.44), no large foreign city has a better telephone development than the first thirty-five ranking cities in the United States, nine of which are among the cities shown on the accompanying chart "Telephones per 100 Population of Large Cities." It is interesting to compare the telephone development of Europe's larger cities with that of the metropolitan



centers of the United States. Thus, New York had 20.83 telephones per 100 of its inhabitants, whereas London had only 9.07. Chicago had 22.35, against 10.85 for Berlin. Los Angeles had 25.75, while Paris had 14.18.

TELEPHONE DEVELOPMENT OF LARGE CITIES
January 1, 1934

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ARGENTINA:			
Buenos Aires	2,970,000	179,154	6.03
AUSTRALIA:			
Adelaide	313,000	27,692	8.85
Brisbane	301,000	25,107	8.34
Melbourne	996,000	94,779	9.52
Sydney	1,240,000	108,679	8.77
AUSTRIA:			
Graz	160,000	8,019	5.01
Vienna	1,900,000	159,478	8.39
BELGIUM: **			
Antwerp	530,000	38,993	7.36
Brussels	966,000	103,580	10.72
Liege	427,000	23,001	5.39
BRAZIL:			
Rio de Janeiro	1,717,000	55,460	3.23
CANADA:			
Montreal	1,017,000	164,184	16.14
Ottawa	186,700	35,256	18.88
Toronto	757,000	184,982	24.44
Vancouver	189,000	51,888	27.51
CHINA:			
Canton	1,050,000	7,300	0.70
Hong Kong	850,000	14,871	1.75
Peiping	1,520,000	12,390	0.82
Shanghai ††	1,500,000	49,401	3.29
CUBA:			
Havana	780,000	26,801	3.44
CZECHOSLOVAKIA:			
Prague	910,000	45,451	4.99
DANZIG:			
Free City of Danzig	263,000	16,725	6.36
DENMARK:			
Copenhagen	813,000	165,518	20.36
FINLAND:			
Helsingfors	265,000	36,962	13.95
FRANCE:			
Bordeaux	267,000	19,551	7.32
Lille	202,000	16,954	8.39
Lyons	667,000	35,345	5.30
Marseilles	895,000	32,428	3.62
Paris	2,900,000	411,249	14.18
GERMANY:#			
Berlin	4,205,000	456,304	10.85
Breslau	625,000	40,192	6.42
Cologne	758,000	62,254	8.21
Dresden	726,000	58,560	8.07
Dortmund	582,000	22,826	3.92
Essen	660,000	28,748	4.35
Frankfort-on-Main	648,000	59,752	9.22
Hamburg-Altona	1,643,000	150,292	9.15
Leipzig	766,000	63,369	8.27
Munich	738,000	74,152	10.05
GREAT BRITAIN AND NO. IRELAND:#			
Belfast	415,000	17,945	4.32
Birmingham	1,200,000	59,248	4.94
Bristol	415,000	21,015	5.06
Edinburgh	442,000	31,873	7.21
Glasgow	1,190,000	58,806	4.94
Leeds	512,000	24,135	4.71
Liverpool	1,196,000	57,993	4.85
London	9,170,000	831,800	9.07
Manchester	1,100,000	64,402	5.85
Newcastle	470,000	19,527	4.16
Sheffield	518,000	19,829	3.83
HAWAII:			
Honolulu	138,000	15,446	11.19
HUNGARY:			
Budapest	1,350,000	74,743	5.54
Szeged	140,000	1,898	1.36
IRISH FREE STATE:#			
Dublin	424,000	18,972	4.47

TELEPHONE DEVELOPMENT OF LARGE CITIES (Concluded)

January 1, 1934

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ITALY:			
Milan	1,025,000	84,956	8.29
Naples	1,000,000	26,135	2.61
Rome	1,045,000	79,247	7.58
JAPAN:#			
Kobe	837,000	32,482	3.88
Kyoto	1,027,000	40,695	3.96
Nagoya	990,000	33,243	3.36
Osaka	2,654,000	117,104	4.41
Tokio	5,486,000	195,225	3.56
LATVIA:#			
Riga	417,000	23,134	5.55
MEXICO:†			
Mexico City	1,100,000	51,492	4.68
NETHERLANDS:			
Amsterdam	778,000	54,952	7.06
Haarlem	159,000	11,975	7.53
Rotterdam	608,000	39,677	6.53
The Hague	508,000	48,262	9.50
NEW ZEALAND:#			
Auckland	214,000	21,262	9.94
NORWAY:*			
Oslo	250,000	50,763	20.31
PHILIPPINE ISLANDS:			
Manila	390,000	17,136	4.39
POLAND:			
Lodz	875,000	13,360	1.53
Warsaw	1,230,000	56,839	4.62
PORTUGAL:			
Lisbon	630,000	26,455	4.20
ROUMANIA:			
Bucharest	670,000	21,450	3.20
RUSSIA:			
Leningrad	2,800,000	76,933	2.75
Moscow	3,700,000	117,619	3.18
SPAIN:			
Barcelona	1,050,000	47,212	4.50
Madrid	980,000	56,558	5.77
SWEDEN:			
Gothenburg	253,000	41,965	16.59
Malmö	132,000	20,329	15.40
Stockholm	438,000	139,933	31.95
SWITZERLAND:			
Basel	150,000	30,208	20.14
Berne	113,000	23,250	20.58
Geneva	146,000	26,589	18.21
Zurich	263,000	53,799	20.45
UNITED STATES: (See Note)			
New York	7,180,000	1,495,922	20.83
Chicago	3,575,000	799,122	22.35
Los Angeles	1,364,000	351,174	25.75
Pittsburgh	1,007,900	182,483	18.11
Total 10 cities over 1,000,000 Population	22,020,600	4,393,541	19.95
Milwaukee	754,900	132,991	17.62
San Francisco	681,000	238,384	35.00
Washington	506,300	178,761	35.31
Minneapolis	502,000	116,145	23.14
Total 10 cities with 500,000 to 1,000,000 Population	6,445,300	1,289,569	20.01
Seattle	414,000	101,398	24.49
Denver	298,000	85,215	28.60
Omaha	236,300	58,780	24.88
Hartford	234,300	51,640	22.04
Total 33 cities with 200,000 to 500,000 Population	9,832,900	1,723,484	17.53
Total 53 cities with more than 200,000 Population	38,298,800	7,406,594	19.34

NOTE: There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups, and the development of certain representative cities within each of such groups.

† January 1, 1933. * June 30, 1933. ** February 28, 1934. # March 31, 1934.
†† International Settlement and French Concession.

The table headed "Telephone Development of Large Cities" gives further details of the development of the more important cities in the various countries of the world. Statistics are presented also for the telephone development of American cities according to various population classes, which may be summarized as follows:

	Telephones per 100 Pop.
10 cities with more than 1,000,000 population	19.95
10 cities with 500,000 to 1,000,000 population	20.01
33 cities with 200,000 to 500,000 population	17.53
53 cities with over 200,000 population	19.34
All communities with more than 50,000 population	18.54

These figures indicate clearly the consistently high telephone development prevailing throughout the United States. In other countries, telephone service is generally concentrated in the larger cities. London had more than 37 per cent of all the telephones in Great Britain and Northern Ireland, Berlin more than 15 per cent of the German telephones, Paris over 30 per cent of the French telephones, Stockholm more than 23 per cent of the Swedish telephones. By way of contrast, New York had less than 9 per cent of the telephones in the United States, and Chicago less than 5 per cent.

K. FICK

Notes on Recent Occurrences

DR. JEWETT HONORED BY BRITISH ENGINEERS

DR. FRANK B. JEWETT, Vice President of the American Telephone and Telegraph Company and President of the Bell Telephone Laboratories, was the recipient, on May 2, of the Faraday Medal, the highest honor bestowed by the Institution of Electrical Engineers, of London. The presentation was made at a meeting of the organization held in the British capital.

The medal was presented by Dr. W. M. Thornton, President of the Institution, and an address setting forth Dr. Jewett's contributions to the development of communication was delivered by Frank Gill. Mr. Gill was for many years an executive of the European branch of the Western Electric Company and as such was closely associated with developments in which Dr. Jewett played an important part. In outlining Dr. Jewett's career, he referred to the extension of telephone service in America until it had become continent-wide in its reach, and to the development of overseas radio telephone service. He pointed out that the Bell Telephone Laboratories, of which Dr. Jewett is the head, and Dr. Jewett himself as an individual had made outstanding contributions to these communication developments.

In a brief address of acceptance, Dr. Jewett expressed his satisfaction in the cordial relationships existing between American and British engineers and scientists in the field of electricity. He outlined some of the steps which have been taken in America toward stimulating interest on the part of graduates of scientific and engineering schools in research work in the communication field.

The Faraday Medal, established by the Institution in 1922,

is of bronze. It is awarded "for notable scientific achievement in electrical engineering, or for conspicuous services rendered to the advancement of electrical science." In awarding the medal, recipients are selected without restriction as to nationality, country of residence or membership in the Institution. Dr. Jewett is the second American who has been honored by the award. Elihu Thomson, distinguished engineer in the field of electric light and power, received the Faraday Medal in 1927. Since Dr. Thomson is of English birth, Dr. Jewett becomes the first American-born scientist to receive the award.

JAPANESE CONFER ORDER OF RISING SUN ON BELL LABORATORIES ENGINEER

THE Imperial Order of the Rising Sun was recently conferred on G. W. Gilman, of the Transmission Development Department, Bell Telephone Laboratories, by Minister of Communications Tokonami of Japan. The award was in recognition of Mr. Gilman's coöperative efforts in the preparations for radio telephone service between the United States and Japan. At the same time, Mr. Tokonami expressed his appreciation of Mrs. Gilman's assistance in these preparations.

During the year that Mr. and Mrs. Gilman spent in Japan, elaborate preparation for connecting Tokyo with various world centers by short-wave radio telephony was in progress. Mr. Gilman coöperated with the Japanese engineers in the testing of the equipment to be used on the service to the United States and in the formulation of routine testing and operating procedures to be followed upon the opening of service. He also represented the American Telephone and Telegraph Company in matters pertaining to the contractual arrangements for this service. Mrs. Gilman assisted in the training of traffic operators, instructing them in the pronunciation of names and the use of terms and expressions that are more or less standardized in the United States.

Other Bell System engineers and scientists who have been honored by the Japanese government include the late John J. Carty, who was decorated by the Emperor in 1909 with the Order of the Rising Sun and in 1912 with the Imperial Order of the Sacred Treasure of Meiji; Dr. Frank B. Jewett, who received the Order of the Rising Sun in 1923 and the Order of the Sacred Treasure in 1930; and Bancroft Gherardi, who received the Order of the Rising Sun in 1923.

TWO-WAY TELEPHONE CONVERSATION IS HELD ENTIRELY AROUND THE WORLD

THE human voice traveled around the world for a new distance and time record on April 25 when President Walter S. Gifford of the American Telephone and Telegraph Company talked over a 23,000-mile telephone and radio circuit which originated and terminated in the Long Lines building in New York City. "This is another step in the conquest of time and space by man," said Mr. Gifford to Vice-president T. G. Miller, head of the Long Lines Department, "and proves there are no earthly limits to human speech."

In this first demonstration of a two-way telephone call around the world, Mr. Gifford used the longest telephone circuit ever established. The route of the call was through San Francisco, Java, Amsterdam, London, and back to New York.

From New York Mr. Gifford's voice crossed the continent over wire through St. Louis and Los Angeles to San Francisco, and then to the Bell System's short wave transmitting station at Dixon, California. From this station Mr. Gifford's voice was transmitted 9,000 miles across the Pacific to the overseas telephone terminal of the Netherlands Telephone Administration at Bandoeng, Java. Here it was transferred to another short wave radio telephone circuit spanning the distance of 7,000 miles to Amsterdam. By submarine cable beneath the North Sea the voice path led over wires and cables to the Lon-

don trunk exchange and thence to the Rugby radio station of the British Post Office. At Rugby the voice impulses were again sent out by short wave radio and were received at the American Telephone and Telegraph Company station at Netcong, New Jersey. The remainder of the route was over telephone cable.

Mr. Miller's answering voice sped in the opposite direction. At Lawrenceville, New Jersey, it was put on the air to be received at Baldock, England. Thence it went by wire through London to Amsterdam, where a short wave radio telephone station once more sped the voice impulses through the ether to Java. Thence the final radio stage was to California, and by wire and cable back to New York.

The circuit linking the two telephones, which were actually within fifty feet of each other, was more than 23,000 miles long. The voice impulses covered this distance in a quarter of a second. Following his informal conversation with Mr. Miller, Mr. Gifford called the roll of the various points through which the circuit passed, speaking in turn with the telephone engineers at San Francisco, Java, Amsterdam and London.